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THE GEGENSCHEIN OR ZODIACAL COUNTER GLOW.

E. E. BARNARD.

Many people not over familiar with the work of an astronomer think that his occupation in the main is to sit at the telescope night after night and gaze on the mysterious and wonderful landscape of the Moon. These same people will sigh for the astronomer when the Moon finally withdraws its wonders from the sky for a few days near new Moon, and will doubtless wonder what he can find to do and to study until it again returns.

No one questions the wonderful charm contained in a view of the lunar world, and its mountains and craters and vast silent plains where the husbandman's voice can never be heard.

But the Moon is a very small consideration indeed to a large majority of observers. Of course when it is around they look at it once in a while and wish they knew more about its mysteries. Many of these observers, however, wish it were away and that it never would return again, and if they were put to it they would declare that they could not see any use in the Moon anyway outside of helping to run the tides and to sometimes guide the occasional sailor along his watery way, and to suppyly light for silly lovers to coo by, and certainly all these things could get along easily enough by themselves, especially the last, if there were no Moon at all.

For these beautiful moonlight nights, that are so successful in producing love and poetry, are the bane of a certain class of observers, for the silvery beams which so beautifully and softly illuminate the landscape also illuminate the atmosphere, and by whitening the sky blot out from view a host of the most important and interesting of the "citizens of the sky." The glories of the Milky Way—the most superb of all the wonders of the sky—are lost in all this glare of lunar light. They require the untouched blackness of space to set off the richness of their beauty. The mysterious and beautiful nebulæ—the original matter from which all things come according to the Nebular Theory—are lost; their filmy light requires a clear moonless night to present them in all their beauty. The mighty comet also loses its grandeur in

a moonlit sky, and that one which would otherwise have made a record passes away scarcely noticed, if its display be coincident with a bright moon.

It is true the planets do not suffer from the presence of the Moon, and the whitening of the sky on which they shine is rather an improvement than otherwise. This may be said also of the individual fixed stars.

There is one thing in the sky, however, that the least glimpse of moonlight most totally anihilates, and there is perhaps more mystery connected with this object than with any other in the entire heavens. Very few people have seen it—indeed I don't think there are many scores of people on the face of the Earth who have seen it. And there are comparatively few who have ever heard of it. The lack of familiarity with this mysterious object is in no wise due to a lack of powerful instruments, for it is wholly invisible in any telescope—nor is it due to the smallness of the object, for it is certainly the biggest thing in the sky so far as appearance goes.

This object which defies the power of the telescope, has been known for about half a century, yet in all that time we have found out very little about it and have so far come to no satisfactory conclusion as to its nature.

In the first half of the century a German astronomer, Brorsen by name, in watching the face of the sky on moonless nights, noticed a large feeble glow of very diffused light in the midnight sky. This feeble light was from 10° to 15° in diameter. He soon found after a few observations that the object was moving nightly towards the east among the stars. A series of naked-eye observations soon showed him also that it was not only moving easterly among the stars, but that it was exactly opposite the Sun and always remained so, and that its center lay exactly in the ecliptic. So exactly did it move with and in opposition to the Sun, that if an imaginary line were passed from the Sun through the center of the Earth and prolonged to the sky it would always pass through the center of this queer object. This fact being established, suggested to the Germans a name for it—they accordingly called it the Gegenschein—a combination of two words *gegen*, opposite, and *schein*, light, meaning a light in opposition.

It seems after this, for a time to have been neglected, if not almost forgotten.

In 1871, however, it was again independently discovered by Mr. T. W. Backhouse at Sunderland, England, who secured

observations, that confirmed its opposition to the Sun. But even this second discovery did not attract attention to it as it should have done, and many people still doubted its existence.

In 1883 about October 1st the writer in seeking comets at Nashville, Tennessee, one night happening to look up to rest his eyes, saw a faint hazy glow near the constellation of Pegasus. This was thought to be a bit of local haze, though it seemed abnormally permanent. The next night it was seen again and was therefore no ordinary haze. A few nights' location of its position showed that it was moving along the ecliptic eastward about one degree a day. Could it be an immense comet? It was certainly no ordinary meteorological phenomenon.

The positions obtained were sent to an eminent astronomer with the suggestion that it might be some extraordinary kind of comet. He wrote back that I had discovered the Gegenschein.

Since then I have been very much interested in the object and have made numerous observations of its position. From these observations some new facts have been developed concerning this remarkable phenomenon.

I have said that this object defies the power of the telescope; this is true. From its great size and diffuse nature no telescope can grapple with it, its feeble light being destroyed by the power of the instrument and the want of contrast—the largest field being vastly smaller than the Gegenschein. Though it can not be seen with any telescope, it is nevertheless a decidedly noticeable object with the naked eye when you know where to look for it.

Just what this mysterious light is no one has yet been able to satisfactorily explain.

Professor Arthur Searle of the Harvard College observatory has made an extensive study of the Gegenschein and is inclined to believe it due to an infinite number of small asteroids.

Between the orbits of Mars and Jupiter are known to be no less than four hundred small planetary bodies. It is probable there are thousands and possibly millions more of these dust worlds. The smaller ones found in recent years are pehaps not over 10 or 15 miles in diameter. As they decrease in size doubtless they multiply in number until finally they exist in untold multitudes of a size comparable with small stones and particles of dust, which no telescope will show individually. Each one of these small bodies is a miniature planet and must shine as a planet by reflecting the light of the Sun. It therefore must present to us phases just as Mars does, but from the smallness of the objects we cannot see these phases—but none the less they

must have an effect on the brightness of each little asteroid, and must diminish its light accordingly.

Let us assume there are a sufficient number of these tiny planets —though they may be too small to be seen individually in a telescope yet their combined light may be so great as to affect the eye and thus we might expect to see a feeble zone of light extending across the sky and corresponding to the asteroidal zone. Such we actually have in the zodiacal band. What would be the effect of phase of these individually small bodies upon the appearance of this zone of light? When opposite the Sun each of the objects would shine with full enlightened disc, and this vast collection of fully illuminated particles would augment the light of the zone and give a greater luminosity immediately opposite the Sun. Away from opposition and the phase would begin to diminish the quantity of illumination. To this must also be added the fact that at opposition each asteroid would be nearer us and brighter from this cause also. Both causes tending to give a maximum of light opposite the Sun—a gegenschein.

This theory certainly appears very plausible, but there are objections to it.

There is one thing certain, if the gegenschein is not really an atmospheric phenomenon—and everything except the fact of its existence seems to go against this supposition—it is at a considerable distance from us. Careful observations have shown no evidence of parallax. Of course observations of such an indefinite object cannot be made with anything approaching to accuracy, but if it were at no greater distance than 100,000 miles, its parallax would have shown in the observations.

That a satisfactory explanation of this most singular phenomenon will be arrived at when it has been sufficiently observed there is no doubt. Therefore it is very desirable that as many careful observations of its position and descriptions of its appearance as possible should be obtained.

Here is a field which offers a splendid opportunity for amateurs to do new and valuable work where no instrument whatever is needed—nor indeed can be used. All that is required is a star chart and an approximate knowledge of the time—to within an hour or so. The observer will find much to interest him in watching this—one might almost say—uncanny thing as it circles the sky with its slow and measured pace.

The gegenschein is best seen in September and October when it is passing from Sagittarius to Pisces. It is then a large and roundish glow, some 15° or 20° in diameter. After passing the

vernal equinox it becomes elongated and is connected with a zodiacal band. The position of its center should be carefully located with reference to neighboring stars, and a description of its appearance given. A knowledge of the point in the sky opposite the Sun should be avoided, as it might bias the observer in his location of the gegenschein.

In the fall of 1893 systematic observations were carried over the two months of September and October to decide certain questions concerning it. One of these points was to show whether there was any observable parallax to the object.

Professor Bailey at the Arequipa (Peru) station of the Harvard College Observatory was to make observations in the southern hemisphere, while observations north of the equator were to be carried on by Professor Searle of Harvard College Observatory and by the writer at the Lick Observatory. These observations will be discussed by Professor Searle as soon as the southern reports are in. Thus we have for the first time simultaneous observations of the gegenschein made from opposite hemispheres of the Earth.

These will definitely settle the existence of any parallax as large as 1° or 2°. However there is no question but this will be settled in the negative—that is, the object, if it is not an atmospheric phenomenon, must be farther away from us than half the distance of the Moon.

That the object is intimately connected with the zodiacal light there is no doubt, and the explanation of the one doubtless rests upon that of the other.

Mt. Hamilton, 1894, Feb. 1.

LIFE AND WORK OF E. E. BARNARD.*

S. W. BURNHAM.

In 1881 Barnard began to search for new comets with his five-inch telescope, and very soon discovered the comet known in astronomical works as Comet VI. This was quickly followed by Comet 1882 III, and in the succeeding year by Comet 1884 II (a comet of short period, 5.4 years, due again in 1895). The next year, 1885, yielded two new comets, 1886 one, and three more were discovered in 1887. Nearly every year since beginning this work he had found one or more of these strange celestial visitors. In

* Continued from January number. This is the second of a series of articles portions of which have already appeared in *Harper's Magazine*, August, 1893.

the seven months from October, 1886, to May, 1887, he discovered four new comets. He discovered every comet of the year 1891. Many of these have proved to be of more than common interest, in consequence of their periodic returns and peculiarities of motion in the approach to and recession from the Sun.

In 1883 he left the photographic business, having received a fellowship in Astronomy at the Vanderbilt University. During these preceding years he had given all his spare time to study, working in the day time, and studying alone at night, and had acquired a good education in the ordinary branches of knowledge. He was promptly placed in charge of the Observatory attached to the Vanderbilt University, and continued his researches with the 6-inch equatorial. This instrument was superior in power to that previously used, and having a fixed equatorial mounting, with driving clock and micrometer, it was much better adapted to the work of determining the absolute positions of unknown objects. While connected with the Observatory, he took in the University a thorough course in English, French, German, Mathematics and Physics; and graduated from the School of Mathematics in 1887. Work with the telescope was constantly going on, and in addition to many other discoveries and observations he found eight comets during the time of his connection with the University, one of them completing its circuit about the Sun in less than five and a half years and having next to the shortest period known. By this time he had become known throughout the world as the leading observer of comets, and an authority upon the subject generally. Since that time he has found not less than ten new comets, and now stands at the head of all living astronomers in the number of comet discoveries.

While he was still at Nashville, and working his way through the University, he had an opportunity of turniug his astronomical discoveries to a very practical account. Mr. H. H. Warner of Rochester, N. Y., in connection with the Warner Observatory, offered a prize of $200 for the discovery of each new comet. The zeal and industry of the young astronomer in this field were duly rewarded; and the amounts thus received were turned to good account in supplying him with books and other necessary accessories and enabled him to make the most of his opportunities. In this way Mr. Warner's liberality in rewarding these discoveries was a more permanent and valuable contribution to astronomical science than he could have imagined at that time.

The work at Nashville was by no means confined to comets. The astronomical journals of that time, show a great variety of

observations. One of these discoveries may be mentioned because it is unique, and illustrates his remarkable skill as an observer and his ability to detect and interpret unsuspected phenomena. In 1883 he was observing an occultation of the well known star β Capricorni, by the Moon. It is probably well known to most readers that when the Moon passes between the observer and a fixed star, the disappearance of the latter is absolutely instantaneous. This is because the star at the distance from which we look at it, is a point only, and, as the Moon has no surrounding atmosphere, the instant the edge of the lunar surface touches the line joining the eye of the observer and the star, the star vanishes from sight. When the Moon passed in front of the star referred to, the observer noticed that instead of disappearing instantly, the process was gradual. The interval between the diminution, and complete extinction of the light occupied only a few tenths of a second, but it was long enough to put the expert observer upon inquiry, and was evidently a matter requiring explanation. Mr. Barnard called attention to this curious phenomenon in one of the astronomical journals, and suggested that the most probable explanation was that this star, always heretofore known as one of the ordinary type, was really composed of two stars, so extremely close together that to the ordinary telescope they appeared as one star. It was also inferred that one of these stars must be considerably brighter than the other from the fact that at the beginning of this fraction of a second, the change in brightness was less than at the end. Subsequent examination of this star with the 6-inch telescope with which the occultation was observed, failed to show any peculiarity in it under the highest powers, and therefore the attention of astronomers with more powerful telescopes was called to the matter. The 18½-inch equatorial of the Dearborn Observatory at Chicago was subsequently turned on this object by the writer, and it was seen to be a close and unequal double star, and one which taxed the powers of that splendid instrument to show it even to a trained eye. A set of micrometrical measures of the two stars was made at this time, and it was subsequently measured with the still more powerful telescope at Mt. Hamilton, and these observations make it highly probable, if not certain, that this double star is an interesting binary system, the two stars revolving about their common center of gravity in perhaps several hundred years.

His discoveries of Nashville include many new nebulæ. There is very little, if any, difference in appearance between a faint tele-

scopic comet, and a correspondingly faint nebula, as seen in the telescope; but the class to which the unknown object belongs is soon determined by measuring its position with reference to some adjacent star. If it be a comet it will soon change its place in the sky, and occasionally the unknown object will turn out to be a nebula which had escaped the vigilant search of the Herschels, and other distinguished observers in this field.

He independently discovered in 1883 that singular phenomenon called the "Gegenschein," which is an extremely faint diffused light seen at times in the sky at night, at points exactly opposite the Sun. It is always difficult to see, and even now but few of the astronomers of the world have seen it, although it was first discovered many years ago by a German astronomer. The cause of this appearance is still a mystery.

In 1888 he was offered a position in the Lick Observatory then about to be opened with the largest equatorial and the best equipment of astronomical instruments in the world. The temptation of superior facilities for astronomical work and discovery, and the opportunity to devote his whole time and strength under these circumstances to the work of his life, left no hesitation in regard to his future course; and much to the regret of the University, and the citizens of Nashville generally he left for Mt. Hamilton, and commenced with increased enthusiasm a series of brilliant observations and discoveries which are familiar to the astronomical world, and to the readers of scientific literature.

It is impossible within the limits of this article to do more than briefly refer to a few of these achievements. They are recorded in the standard astronomical periodicals and publications of the world. In the volumes of the publications of the *Royal Astronomical Society*, *the Astronomische Nachrichten*, the *Astronomical Journal*, the *Sidereal Messenger*, and many others, will be found scores of papers, not of a speculative or descriptive character, but founded upon original observations, and forming valuable contributions to our knowledge of the universe beyond.

Reference has already been made to the new comets discovered by Barnard on Mt. Hamilton from 1888 to 1892. These were systematically measured from night to night, with the micrometer and the same line of observations followed with regard to the comets discovered by other observers, as well as the returns of the various periodic comets. Many of these bodies were observed long after they had passed beyond the reach of other astronomers. Comet V of 1889 was followed for nearly a year after it had become so faint as to be invisible at all other observatories.

In the course of his observation of these bodies for the determination of their places and motions around the Sun, many curious things were found out concerning these mysterious visitors. In August, 1889, he discovered that Brook's comet of that year was passing through space with four minute comet satellites, moving generally with the parent body, but with some relative motion of their own. Nothing of this kind had ever been observed before, and it naturally attracted a great deal of attention from the scientific world. Some of these objects were very faint and could only be seen by experienced observers with large instruments. They were fully measured by Barnard at every available opportunity as long as they were visible, and a valuable paper embodying these observations was published by him in the *Astronomische Nachrichten*. His observations of new and periodic comets have always had a special value from the fact that in consequence of his keenness of vision and experience in observing faint and difficult objects of this class, aided by superior instruments for the work, he has carried his measures far beyond the time when these objects had ceased to be visible to other observers. With the large telescope at Mt. Hamilton he followed one of his comets (I 1889) more than one hundred millions of miles beyond the orbit of Jupiter. The extreme distance at which any previous comet had been seen was much less than the distance of Jupiter.

SHOOTING STARS.

How to Observe Them and What They Teach Us.

W. F. DENNING.

VIII. The Andromedes of Biela's Comet.

Though we do not appear to possess any ancient records of this shower, its modern history is so interesting and its cometary correlation so remarkable that it undoubtedly takes a prominent place in this department of astronomy. It has furnished no less than three brilliant displays during the last quarter of a century, namely, on November 27 in 1872 and 1885, and on November 23 in 1892. Similar exhibitions will probably occur in 1898, 1905 etc. There are visible features connected with this system which render it especially worthy of attentive study. The Perseids, Leonids and Orionids have rendered us familiar with the swift,

streak-leaving meteors, but the Andromedes present us with another and a more interesting type, for they move very slowly and leave trains of yellowish sparks. From the relative positions of the orbits of the Earth and meteor stream at the time of the rencontre, the meteors have virtually to overtake the Earth, and thus their apparent velocity is near the absolute minimum of these phenomena. In fact the apparent motion of the Andromedes is only about ten miles per second, whereas that of the Leonids is about forty-four miles per second, for the latter represent the very swiftest class of these bodies.

The radiant of the Andromedes is a very singular one, for it comprises an area several degrees in diameter on the N. W. side of γ Andromedæ, and only three or four degrees distant from that star. For the great shower of Nov. 27, 1872, Professor Herschel found the mean place at $24°.54 + 44°.74$ from 90 observations by different observers. For the similar display in 1885 I derived the mean place at $23°.7 + 44°.3$ from thirty-three independent observations.

As to the diffuseness of the radiation Professor Herschel found from his observations in 1872 that 60 per cent of the meteors he recorded indicated a circular area about 5° in diameter. In 1885 Mr. Cowper Ranyard thought the area to be elliptical with its major axis N. and S., some 12° or 15° long, and a minor axis of of 6° or 8°. Professor Young also found it oval, and stated it to be 4° long, N. and S., and 2° wide. At Bristol the writer estimated it at about 7° diameter, but recognized no peculiarity of shape. In 1892 Professor Young alluded to the shower of Nov. 23 in that year as giving a "radiant not well defined, its area being at least 4° in diameter."

Another singularity in connection with the radiant is that its position undergoes considerable variation during the day of 24 hours. This has not been fully demonstrated from observation, but the late Joseph Kleiber's theoretical investigations prove that the attraction of the Earth must occasion a large displacement of the radiant as observed at different hours. His computed positions for it at intervals of three hours from noon on Nov. 26 to noon on Nov. 29 are given as follows in *Monthly Notices*, Vol. III, p. 352–3:

POSITIONS OF THE ANDROMEDÆ RADIANT.

Hour.	Nov. 26.	Nov. 27.	Nov. 28.
	° °	° °	° °
0	16.96 + 51.08	18.04 + 51.60	19.12 + 52.18
3	15.14 + 47.40	16.22 + 47.98	17.30 + 48.56
6	17.09 + 44.62	18.07 + 45.20	19.25 + 45.78
9	20.60 + 43.33	21.68 + 43.91	22.76 + 44.49
12	24.92 + 43.78	26.00 + 44.32	27.08 + 44.90
15	28.98 + 46.25	30.06 + 46.83	31.14 + 47.41
18	29.21 + 50.23	30.29 + 50.81	31.37 + 51.39
21	24.04 + 53.56	25.12 + 54.14	26.20 + 54.72

The following diagram, taken from one by Mr. Kleiber, exhibits in a graphic manner the curious, roughly circular motion of this radiant.

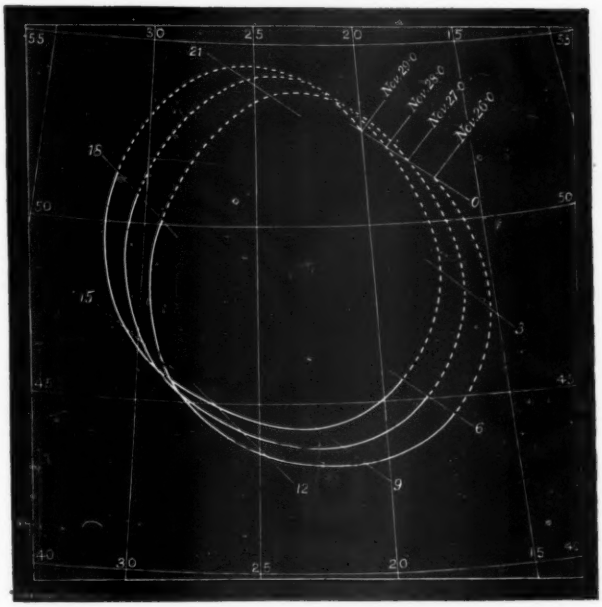


FIG. 10. MOTION OF THE RADIANT OF ANDROMEDES.

The table and diagram given above will scarcely, however, apply correctly to future returns of the shower as, from the observations in 1892, they will probably occur on Nov. 23 instead of on Nov. 27 as formerly. This is confirmed by M. Bredichin in a paper published in the *Astronomische Nachrichten*, No. 1219, in which he states "the descending node of the stream has receded

almost 4° to the west between 1885 and 1892. The cause of this is due to Jupiter, the perturbations set up by this planet accounting for the mean daily motion which is nearly equal to that possessed by Biela's comet. An approximate computation of the special perturbations for the whole period during which Jupiter had any influence, gave for the recession of the node a little over 4°, the inclination decreasing about 0°.6." From this it will be seen that the alteration of date in the shower's return is distinctly attributable to the disturbing action of Jupiter and that observation and theory are in excellent accordance as to the extent of the disturbance.

A great number of minor showers manifest themselves simultaneously with the Andromedes, but they appear to be similar in many cases to those accompanying the Leonids a fortnight earlier in the same month. It will therefore be unnecessary to enumerate them in anything like a complete manner, but a short list is appended of 15 radiants comprising some of the best visible at this epoch:

METEORIC RADIANTS VISIBLE NOV. 25-30.

° °	° °	° °
27 + 71	61 + 37	155 + 40
31 + 37	63 + 21	162 + 58
44 + 56	70 + 66	190 + 58
48 + 42	74 + 41	194 + 43
60 + 49	79 + 23	332 + 58

The majority of these may be expected to prominently attest their existence in future years.

More observations of the Andromedes will doutless elicit some further interesting developments. Among the features requiring attention may be mentioned the following:—

1. Are some of the meteors visible every year? Existing observations are insufficient to settle the point. If the stream recurs annually it must form a complete ellipse like the Leonids, Perseids and many other showers.

2. What is the diameter of the radiant area? Is it oval or circular? Very accurate mapping of a number of paths near the radiant will be necessary to define this.

3. What are the horary positions of the radiant centre during the night? It is very desirable to ascertain this in order to practically test Mr. Kleiber's deductions. It may easily be done during a really active return of the shower; indeed the radiant might then be deduced every half or quarter of an hour and the resulting series of positions would offer an excellent means of comparison with those derived from theory.

4. What is the duration of the shower? In 1872 the display appears to have been limited to the 27th, whereas in 1885 it continued from November 25th to 30th. The Earth undoubtedly traverses the very rich portion of the stream in a few hours, but it is desirable to note how long the radiant is in evidence even in a feeble state. Observations should be conducted from the middle to the end of November and special efforts should be made in 1898 or any other year promising an abundant display.

Some other points might be referred to but for the present the above short summary will suffice. The questions propounded will doubtless be answered at some future time, for observers will never neglect a system possessing such significant relations. We have already determined its radiant accurately, but it must be confessed that our knowledge is very inadequate as regards certain other details of its visible behavior. The story of its physical identity with Biela's lost comet is an old one and need not be told again here, but the circumstance referred to gives a special interest to the stream apart from the great attraction it possesses in itself from the brilliant character of its periodical displays.

HOW TO FIND THE ORBIT OF A DOUBLE STAR BY A GRAPHICAL METHOD.*

S. W. BURNHAM.

With this arrangement we can change the eccentricity of the ellipse very quickly and conveniently, and without making any knot or loop in the other end of the wire, as it is easily held in place by the hand. After experimenting with the foci, axis, etc., until the proposed ellipse is apparently satisfactory for a first attempt, the outline is made in pencil lightly, and the foci marked so that when a second trial ellipse is made, the variation in these points and the length of the Major axis can be quickly made. The next step is to measure the areas of the several portions of the ellipse represented by measures, and ascertain whether they are proportional to the respective times. At first they will probably be only roughly so, but it will be apparent how to improve it in a second trial. This must be done by successive attempts until after a most careful comparison of the apparent orbit with

* Continued from February number, p. 248.

the observations, considered each upon its own merits, the result is considered as satisfactory as can be found.

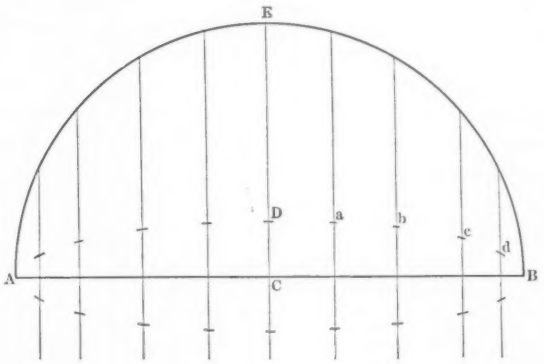
This cannot be done too thoroughly and carefully, since everything depends, in this as in all other methods, upon the accuracy with which the apparent orbit represents the measures. When this is properly done, the elements of the real orbit are readily found. Whatever methods are used, the results should be the same.

It must be borne in mind that the ellipse must represent the distances well. The distances of binary stars when measured by observers of experience with the micrometer, are always better than the angles; and therefore the apparent ellipse should be such that the measured distances fall very near the curve, so that with a reasonable change in the angles they will conform almost exactly. With close pairs, such as we have in nearly all rapid binaries, an expert observer can estimate the distances, which in most instances are considerably less that 0″.5, and down to 0″.1, more accurately than any one can measure the position angles. The reason for this is obvious when we consider how short the base line is for measuring the angle, and how insignificant to the eye a change of even ten degrees from parallelism would be. Some of the old computers attempted to dispense with the distances altogether, and get orbits based on angles alone. However, satisfactory these results may have appeared at that time, it is certain now that the plan was as unreliable in practice as it was in theory. Dr. See has pointed out (ASTRONOMY AND ASTRO-PHYSICS, December, 1893,) that some of the best known orbits at the present time are founded upon the measured distances alone. Such a course was necessary in these instances because the plane of the orbit was almost exactly in the line of sight, and consequently the position angle was practically constant. Of course the logical and scientific way is to use all of the measures, angles and distances, whenever it is possible to do so. It is only in this way we can expect to get the best possible result from the observations.

It is sometimes desirable, especially when the original diagram is to be reduced in the camera for reproduction, that the final ellipse should be put, as the other lines and positions have been, in india ink. This is easily done if a very small hole is drilled in one side of the drawing pen, about one-sixteenth of an inch from the lower end, and a piece of a small wire firmly fastened in the hole, and projecting outwardly sufficient to catch and hold up the string or wire as the pen moves around in describing the ellipse. In this way ink can be used as readily as a pencil.

It will occasionally happen that it is necessary to draw an ellipse so elongated that the string should not be depended on to make a figure which is sufficiently exact. In such a case points should be laid down at various portions of the curve to fix its boundaries. The general form of the ellipse, and the dimensions of the axes can be found in the manner previously described. The following is an easy and accurate method of finding the boundary of such an ellipse.

Lay down the major axis AB and the semi-major axis CD. On AB as a diameter, describe the semi-circle AEB, and then find the ratio of EC to DC. At equal distances from the center of the circle, draw any convenient number of parallel lines at right angles to AB, and on them from the intersection of the respective lines with the diameter, lay down the points *a*, *b*, *c*, etc., having the same ratio to the lines as EC : DC. These points will lie in an ellipse which will be a projection of the circle described on AB, and the ratio of EC to DC will be the cosine of the inclination.



Of course it will only be necessary to find the points *a*, *b*, *c*, etc., for one-fourth of the ellipse, as they will be the same for each quadrant. The most rapid and convenient method of finding these points is by the use of the proportional dividers. By trial the sliding center is set so that when one pair of the points is made to include EC, the opposite pair will give DC. Then all the points can be taken directly by opening the dividers to the distances of the other semi-chords. The points thus found may be transferred to the original diagram; or the last ellipse may be cut out and if on thick paper the drawing pen can be passed around its edge on the original sheet.

Elements of the Orbit.

The final ellipse having been drawn it only remains to find the elements of the real orbit. These elements are:

P = Period.
e = Eccentricity.
a = Semi-major axis.
i = Inclination.
☊ = Node.
λ = Angle of node to periastron.
T = Periastron passage.

Various geometrical methods have been suggested for finding some of the elements from the apparent ellipse, but by far the best is that given by Ball in his valuable *Atlas of Atronomy*, and a considerable part of that is used here, but for the reasons already given, I have preferred to deal directly with the measures themselves, and to deduce the period from direct measurements of the ellipse.

To best illustrate the application of the graphical method as I have used it heretofore, I propose to take the observations of a binary and show how the several elements can be found. For this purpose I have selected $\varkappa$ Pegasi (β 989), one of the most interesting and rapidly moving systems known. In fact it has, as we shall see, a shorter period than any other known pair in the heavens. I have thought it best in this instance to rely entirely on my own measures, and those made at my request by Professor Barnard with the 36-inch at Mt. Hamilton when it was no longer possible for me to continue the series:

Measures of $\varkappa$ Pegasi.

1880.68	137°.9	0″.20	4*n*	Burnham
84.87	104 .7	0 .22	1*n*	Burnham
88.78	274 .7	0 .23	3*n*	Burnham
89.51	262 .3	0 .14	4*n*	Burnham
90.57	187 .1	0 .10	4*n*	Burnham
91.71	147 .3	0 .12	7*n*	Burnham
92.39	132 .8	0 .18	4*n*	Burnham
92.88	131 .0	0 .20	1*n*	Barnard
93.71	121 .7	0 .23	1*n*	Barnard

These positions were laid down on a scale of 0″.1 = 2 inches in the manner already described; and after repeated trials, and a careful measurement of the relative areas, the ellipse shown on the diagram was finally adopted as satisfactorily representing the apparent orbit. Each trial ellipse was measured with sufficient care to show how far it was in harmony with the law of equal areas in equal times. When the last ellipse was laid down, the areas described by the radius vector between the successive ob-

servations was measured with all possible precision. The areas corresponding to the respective measures are as follows:

	Time	Area	t (0.186)
1880 — 84	4.19	7.41	7.79
1884 — 88	3.91	7.15	7.27
1888 — 89	0.73	1.41	1.37
1889 — 90	1.06	2.85	1.98
1890 — 91	1.14	1.61	2.12
1891 — 92	0.68	1.39	1.28
	11.71 =	21.82	
	1 yr. =	0.186	
1880 — 92		0.63	
1892 — 93	1.32	2.08	2.45

We see from the last column, giving the respective areas as deduced from the mean motion, that on the average the angles are represented as well as could be expected in so close a pair. With a single exception, a very small change in the position angles will be sufficient to make the areas strictly proportional to the times. This amount is far within the probable errors in so close and difficult a pair, and as the errors of distance are exceedingly small, and wholly insensible quantities even in the largest telescope, we may fairly conclude that this ellipse must very nearly represent the apparent path of the companion. According to this orbit, the position angle found in 1890 requires a correction of a little more than 10°. The distance at this time was less than at any other observation, and in fact less than 0″.1; and when we remember that most of the old and frequently observed pairs, with distances between the components more than twenty times that of $\varkappa$ Pegasi, have errors in some of the position-angles greater than that in question, we are justified in treating this single variation as not a very serious objection to the acceptance of this ellipse as a satisfactory representation of the apparent orbit.

It will not be difficult from the measures of the areas, to distribute the errors, and find the changes required in the various position-angles to make the corresponding quantities in the last two columns equal, but it is hardly worth while doing this after the comparison already given, and the graphical presentation of the whole subject in the diagram.

The distance errors, measured directly with the scale, are as follows:

1880.68	− 0″.03
84.87	0 .00
88.78	− 0 .02
89.51	+ 0 .02
90.57	− 0 .01
91.71	+ 0 .02
92.39	+ 0 .02
92.88	0 .00
93.71	+ 0 .04

Nothing could be more satisfactory since the variations are all practically zero.

In this example we have more than one revolution. As the last measure is from a single night, I have derived the mean motion from the intervals ending with 1892. To find the period, therefore, we have:

$$11.71 - \frac{.063}{.186} = 11.37 \text{ years.}$$

In this connection it may be well to give a few suggestions in regard to the best way of measuring parts of an ellipse. It may be done in two ways. The first requires only the dividers and the scale previously used. The portion of the ellipse to be measured is separated into a convenient number of triangles by lines drawn from S to the circumference, and the area of each found by multiplying this line as a base by the altitude of the triangle. As the smaller side is a curve, allowance must be made in measuring the altitude. This is easily done, and with great accuracy by drawing a straight line with india ink on any transparent medium like celluloid or mica, and laying this down so that it shall pass through the outer end of the base, and revolving it about that point so that it shall intersect the other line of the triangle produced, and make the areas equal on each side of the curved side. This is done in an instant, and with an accuracy which would be surprising to one who had not tried it. At the end of the work it is easily tested, since the sum of the areas of all these triangles should be equal to the semi-major axis $\times$ semi-minor axis $\times$ 3.1416.

The second method is by the use of the planimeter. This of course is a very accurate way, and very much quicker than any other, as it is only necssary to pass the pointer arm over the lines of the figure to be measured, and read the area directly from the index. The areas previously given of this ellipse were measured with this instrument. The results given are in square inches. The sum of the areas of all the parts of the ellipse, in seven different sections, is 21.19, while a direct measurement of the ellipse as a whole gave 21.13 for the area.

To obtain the other elements of the orbit, draw a line from the center, C, of the ellipse through the principal star, S, to meet the ellipse in P. This will be the projection of the major axis of the real ellipse. Draw a chord H S K through S in such a position that HS = HK. The position of this chord may be determined geometrically, but finding it by trial with most ellipses is suffi-

ciently accurate. This is quickly done by driving a fine needle through S, and revolving the scale at some even division about it until the readings both ways are equal. To find it geometrically, draw any chord parallel to CSP. From the middle point of this chord, draw a line through C, and parallel to this line, draw a line HK through S which will be the chord required.

Take a point D on the line CSP continued so that

$$SD = \frac{CP^2 - CS^2}{CP}$$

In this case we have

$$SD = \frac{.101^2 - .040^2}{.101} = 0''.085.$$

Through the point D draw a line perpendicular to the chord HK, and find points A and B on this line so that DA = DB = SH.

Eccentricity. The eccentricity is unchanged by projection and

$$e = \frac{CS}{CP} = \frac{.040}{.011} = 0.396.$$

Inclination. The inclination of the real orbit to the plane of projection is

$$\cos i = \frac{SB - SA}{SB + SA} = \frac{.106}{.490} = 0.216326.$$

From a table of natural cosines we find this corresponds to 77°.5, which is the inclination of the real to the apparent orbit.

Node. Draw a line from S bisecting the angle ASB and the position angle of this line will be the line of nodes. When expressed numerically this should be always given in the first or second quadrant, and not 180° from that point. It may be found by measuring with protractor the position-angle of A and B and taking a mean of the two for the angle of the node. In this case,

$$SB = 363°.0, \text{ and } SA = 214°.4.$$

Therefore, the line of nodes will be

$$214°.4 + 78°.3 = 288°.7 = 108°.7.$$

This is shown on the diagram by the line NSN.

Semi-major axis. For the semi-major axis of the real orbit we have:

$$a = \frac{SB + SA}{2(1 - e^2)} = \frac{.490}{1.686} = 0''.29.$$

Angle of Line of Nodes and Periastron.

The element λ is the angular distance between the line of nodes

and the major axis, CSP, measured on the real ellipse. We find by the protractor that the position-angle of the periastron or line of the projected major axis is 325°.8, and therefore the angle between this line and the node on the apparent ellipse is 37°.1. To reduce this to the plane of the real orbit take

$$\tan \lambda = \sec. i \times \tan 37°.1$$

$$\begin{aligned} \sec. i\,(77°.5) &= 10.664663 \\ \tan\ \ 37\ .1\ &= \ 9.878691 \\ \hline & 10.543354 = 74°.0 \end{aligned}$$

There has been much confusion heretofore in giving the value of λ. Sometimes the value of Ω has been taken on one side and sometimes the other ($\pm$ 180°); and the distance from N to P has been reckoned in both directions, retrograde and direct. It is usually impossible to tell how the computer has done this without laying down the apparent orbit from the elements. Dr. See has proposed (*Astronomy and Astro-Physics*, August, 1893) to avoid this uncertainty in the future by always counting from Ω, taken in the first or second quadrant, to periastron *in the direction of the motion.* This will make all results uniform, and prevent confusion hereafter. He has adopted this plan in all his investigation of binaries, as I have done, and I trust it will be followed by all others in the future, Attention is specially called to the two important papers on this subject by Dr. See printed in *Astronomy and Astro-Physics* for August and December, 1893.

In accordance with this, we find that this element should be,

$$108°.7 - (288°.7 + 74°.0) = 106°.0$$

Periastron Passage. It only remains to find the time of the passage of the companion though P, the point of nearest approach in the real orbit. This is easily done by comparing the areas on either side of SP with the observed positions. In this way we find T = 1886.0.

In addition to the elements of the real orbit of a binary, the data for platting the apparent ellipse should always be given. This enables any one to lay down in a few minutes the orbit found by the computer, and compare it with the observations used. In no other way can the real value of the work be seen. The usual tabular comparisons of observed and computed positions are entirely insufficient. A good many orbits have been computed by the old methods, and passed without criticism which probably would have been rejected at once by the authors if the ellipse and the measures had been laid down on paper. It

would have appeared then that the result reached was without foundation, and that the lack of sufficient data could not be cured by mathematical formulæ, however, scientifically administered.

Dr. See has devised an an elegant geometrical method of finding the apparent ellipse from the elements of the real orbit (*Astronomy and Astro-Physics*, August, 1893). This will be found to be very useful for laying down orbits to ascertain in what way the measures are represented. Hereafter I hope all investigators of the orbits of binary systems, whatever method may be used, will make their work complete by giving in all cases diagrams showing the apparent orbit, and the observed positions upon which such orbit is based.

Elements of κ Pegasi.

We have the following elements of this binary:

$P = 11.37$ years.
$T = 1886.0$
$e = 0.40$
$a = 0''.29$
$i = 77°.5$
$\Omega = 109\ .2$
$\lambda = 106\ .1$

Apparent Orbit.

Length of major axis = 0″.54
Length of minor axis = 0 .13
Angle of major axis = 110°.0
Angle of periastron = 326 .0
Star from center = 0″.04

The period of this pair was first determined by the writer graphically (*Monthly Notices*, March, 1891), using the measures down to and including 1890, and the time of one revolution found to be 11.13 years. Subsequently Glasenapp (*Monthly Notices*, June, 1892) investigated it, using the measures of 1891, and a single measure in 1892, and made the period 11.54 years. Since that time other measures have been made, and more than one revolution described by the companion since my first measures in 1880.

This orbit differs very materially in most of the elements from those previously referred to. The eccentricity is double that of Glasenapp's, and the inclination much larger. It certainly has a shorter period than any binary of which we have any knowledge. The next in order of time is δ Equulei (OΣ535) for which Wrublewsky (A. N., 2771) in 1887 found a period of 11.54 years. Dr. See has recently investigated it, using the last measures made,

and finds the periodic time to be 11.50 years. As this is based upon four complete revolutions, it is not likely that it will be sensibly reduced hereafter.

I have endeavored to make this plan of investigating the motion of a binary clear and practical, and to avoid befogging it with unnecessary formulæ and complications. I am satisfied that when the purely graphical method comes to be better understood and used, its value will be generally accepted.

VARIABLE STARS. VI.

J. A. PARKHURST.

It will doubtless be of interest to readers of POPULAR ASTRONOMY to learn something of what is being done in the observation of variable stars at the present time, and where the results of the work are published.

In Germany, the land of Argelander and Schönfeld, a number of industrious observers are working at variables. Among them may be mentioned Dr. Ernst Hartwig, Director of the Municipal Observatory at Bamberg, who is observing with a 6-inch refractor of the "comet-seeker" form, mounted in the very convenient way designed by the Repsolds. Dr. Hartwig's observations are published in the *Astronomische Nachrichten*. He also prepares annually an ephemeris of variables for the *Vierteljahrsschrift der Astronomischen Gesellschaft*.

Dr. Otto Knopf, of Jena, observes with an 8-inch Bamberg refractor. In 1892 he made 464 observations of 40 variables. He is a frequent contributor to the *Astronomische Nachrichten*.

Mr. Friedrich Krüger of Kiel has made indirectly an important contribution to the literature of variable stars by publishing in 1893 a "Catalogue of Colored Stars," giving the magnitude, color and spectral type of 2297 such objects including many of the known variables.

Professor A. Safarik of Prague, Austria, has been an industrious variable star observer, though he announces in the last *Vierteljahrsschrift* that he intends soon to bring his observing work to a close in order to devote his time to the reduction and publication of his observations, of which he has about 20,000. In 1892 he made 1727 observations of 140 stars. Professor Safarik has used a 4½-inch refractor, a 6½-inch reflector, and also a refractor whose exact size I cannot find, though it is probably above

6-inches, since he reports observations of minima of S Cassiopeiæ and R. Lyncis, which at that stage are difficult objects for a 6-inch.

Professor N. C. Dunér of Upsala, Sweden, has been observing variables with a 6½-inch refractor. In 1892 he reported 1325 observations. His work is of great value, notably his researches on the peculiar variations of the remarkable Algol type variable, Y Cygni. Professor Dunér is a contributor to the *Astronomical Journal.*

In Russia Professor S. Glasenapp has been observing variables with a 9-inch refractor at Abastuman. He writes frequently for *Astronomy and Astro-Physics.* In Italy, Professor J. Porro observes at Turin with a 4.8 inch refractor.

Among the few variable star observers in the southern hemisphere may be mentioned Mr. Alex. W. Roberts of Lovedale, South Africa, who has communicated some of his results to the *Astronomical Journal.*

A large number of workers in this field are found in Great Britan. Prominent among them is Rev. T. E. Espin of Wolsingham Observatory, Tow Law, near Darlington, who observes with a 17¼-inch reflector, and an 8-inch photographic refractor. The latter gives plates on almost the same scale as the Durchmusterung charts, so that stars can be at once identified by laying the plate on the chart. Any marked change in the brightness of the stars since the epoch of the chart is at once made evident by this operation. Espin also observes stellar spectra with the reflector, and as nearly all variables have the same type of spectrum (Secchi's Type III) a number of new ones have been discovered in this way. Chandler's Second Catalogue contains ten variables discovered by Espin. He is a frequent contributor to the *Astronomische Nachrichten.*

Mr. Geo. Knott of Cuckfield, Sussex, observes with a 7⅓-inch Clark refractor. Mr. Joseph Baxendall, Jr., of Birkdale, Southport, uses a 6-inch Cooke refractor. As an indication of the industry of the Baxendall's, Sr. and Jr., may be mentioned the fact that Chandler's Second Catalogue contains 12 variables discovered at Southport. Mr. Cuthbert E. Peek of Rousdon Observatory, Devon, observes with a 6.4-inch refractor. He makes monthly reports to the *English Mechanic.*

In Edinburg, Thos. D. Anderson is observing. He is renowned for his discovery of the new star in Auriga in Jan., 1892, aided only by a small spy glass and Klein's Atlas. Mr. Anderson has lately discovered a new variable in Cassiopeia, B. D. $+58°$, 2560,

which was bright enough in Dec., 1893, to be seen with a field glass, but 1894, Feb. 21, was about the 12th magnitude. Mr. Anderson thinks that this should be classed as a "temporary star" and not as an ordinary variable, but further observations will be needed to decide as to its classification.

Mr. J. Ellard Gore of Ballysodare, Ireland, is one of the best known British authorities on variable stars. He is the Director of the Variable Star Section of the British Astronomical Association. His two catalogues of variables were mentioned in the March number.

America is by no means behind in this respect, either in the number of observers or the quality of their work. We have with us the greatest living authority on variable stars, Dr. S. C. Chandler, of Cambridge, Mass. The excellence of Dr. Chandler's work lies not only in his own observations, which are made with a 6¼-inch refractor, but in his sifting, comparing and reducing a mass of observations made all over the world, and deducing therefrom the true elements of the variables. This work has been done so well for his "Second Catalogue" that Dr. Hartwig of Bamberg accepts its elements as the basis of his ephemeris for 1894, published in the *Vierteljahrsschrift der Astronomischen Gesellschaft*, Vol. XXVIII. By common consent of astronomers the lettering and numbering of newly discovered variables is left to Dr. Chandler, as the like work for newly discovered asteroids is done by Professor Tietjen of the Recheninstitut of the Berlin Observatory. Dr. Chandler is an associate editor of the *Astronomical Journal* and a frequent contributor to its columns.

Mr. Henry M. Parkhurst of Brooklyn, N. Y., is a veteran observer. His work is done with a 9-inch Fitz refractor and special photometric appliances devised by himself. His observations are published in the *Astronomical Journal* and in the Annals of the Harvard College Observatory. Vol. XXIX of the Annals contains a very important paper giving about 3600 of Mr. Parkhurst's observations of known and suspected variables made between 1883 and 1893, a table of light curves and magnitudes of comparison stars. Dr. Gould calls this "one of the most valuable contributions to the subject which we possess." Continuations of the same series of observations are published in Nos. 308 and 311 of the *Astronomical Journal.*

Mr. Edwin F. Sawyer of Brighton, Mass., is a very careful and accurate observer. He contributes to the *Astronomical Journal.*

Mr. Paul S. Yendell of Dorchester, Mass., is one of the most assiduous variable star observers in the world. His work formed

the basis of a considerable part of Chandler's Second Catalogue. He observes with a 4¼-inch Clacey refractor and contributes regularly to the *Astronomical Journal.* Nos. 309 and 310 contain confirmations by Mr. Yendell of the variation of eight suspected variables.

Rev. J. G. Hagen of Georgetown College, D. C., has observed variables for a number of years with 3 and 5 inch refractors. He takes as his special field the southern variables which are within reach at his latitude.

Mr. S. D. Townley while at Washburn Observatory, Madison, Wis., made a valuable series of observations of faint variables with the 15½-inch Clark refractor. These observations extend from Nov., 1889, to July, 1892, and were printed in Vol. VI, of the Publications of Washburn Observatory.

Frequent notices appear in *Astronomy and Astro-Physics* and the *Astronomische Nachrichten* of the discovery of new variables on the photographic plates taken at the Harvard College Observatory and its southern station at Arequipa, Peru. The discussion which has arisen in regard to these was mentioned in the March number.

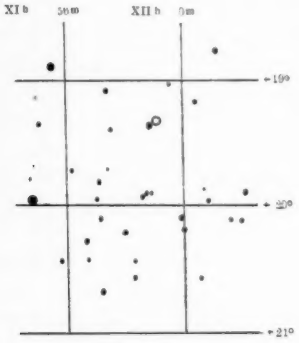
The foregoing account is necessarily incomplete but will give some idea of the work in progress in this department.

Charts of four more variables are presented this month. The following are the principal data concerning them:

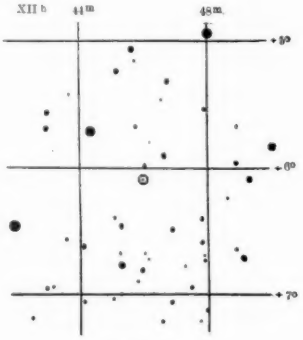
No.	Star. Name.	Place for 1900. R. A.			Decl.		Redness	Magnitude. Max.	Min.	Period days.
		h	m	s	°	′				
4315	R Comæ	11	59	7	+ 19	20.3	4.0	7.4 — 8.0	< 13.5	361
4596	U Virginis	12	46	1	+ 6	5.8	1.1	7.7 — 8.1	12.2 — 12.8	207.0
4847	S Virginis	13	27	47	− 6	40.8	2.6	5.7 — 7.8	12.5	376.4
5194	V Boötis	14	25	42	+ 39	18.5	3.6	6.9 — 7.3	9.2 — 10.5	256

These stars are selected since they become bright enough so that good determinations of their maxima can be made with a two-inch telescope. They will reach their maxima during the coming spring and summer (for reasons before mentioned it is best not to state the times more definitely); and at that time they will be in convenient position for evening observation. V Boötis can be followed through its whole period with a 3-inch telescope. It is easily found, being in the field with the third magnitude star γ Boötis.

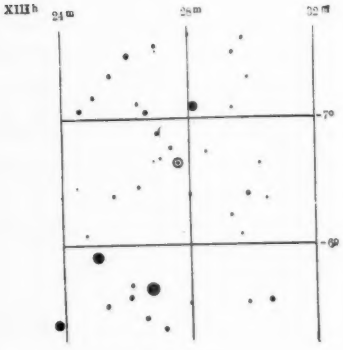
Since writing the note in regard to Mira in the March number that star has increased so as to be visible to the naked eye. Feb. 21st, it was a little brighter than the 5th magnitude.



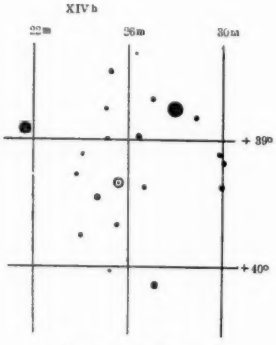
4315 R Comæ.



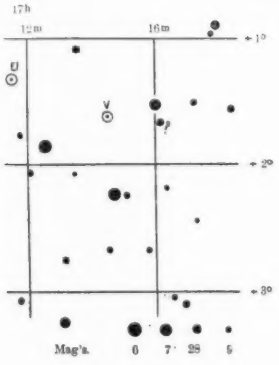
4596 U Virginis.



4847 S Virginis.



5194 V Boötis.



B. D. + 1°, 3417.

Mr. Edward N. Botsford of New Haven, Conn., has ordered a 4½-inch refractor and expects to take part in variable star work.

I have just received the March POPULAR ASTRONOMY containing the announcement of the discovery by Mrs. Fleming of two new variables on the Harvard plates. One of them is

B. D. + 1°, 3417, R. A. $17^h\ 14^m.5$, Dec. + 1° 37′, 1900.

Mrs. Fleming says—"it varies from the magnitude 8.5 to 12.5." I therefore give a chart of the vicinity, the new variable being marked V. The same chart contains the Algol-type variable U Ophiuchi, marked U, and a star marked ? whose magnitude has been variously estimated from magnitudes 7.8 to 9.0, which will bear watching. It is B. D. + 1°, 3422.

MARENGO, Ill., 1894, Feb. 26.

CONSTELLATION STUDY.

WINSLOW UPTON.

VI.

We now take up the constellations in the second division of the heavens—that included between the hour circles of 6 and 12 hours right ascension. We have already considered the circumpolar constellation of this group, the enormous area designated Ursa Major. The constellation Lynx might also have been regarded as circumpolar, but its leading stars are south of 50° declination, and it will be described below.

The zodiacal constellations of this division are Gemini, Cancer and Leo.

Gemini. The two leading stars of this group are Castor and Pollux, or α and β Geminorum. The latter is the southern of the two and though lettered β is appreciably the brighter. They are about 5° apart and are the only especially conspicuous stars between Taurus and Leo. They can also be readily found from Orion, by extending the line from Rigel to Betelgeuse, one and a half times the distance between these brilliant stars. These stars are in the heads of the twins, and the figures are drawn southwesterly with their feet near the boundary of Orion. Two lines of stars may be readily traced, as indicated on the chart, following the respective figures. The northern one follows the body of Castor and the latter that of Pollux. The feet are also marked by stars; ξ and γ are the feet of Pollux and ν and μ those of

Castor. This line of stars, ξ, γ, ν, μ is easily traced, and is near the western boundary of the area. Just west of μ is a star of nearly equal brightness lettered *y*. This is very near the place occupied by the Sun at the summer solstice. The solstitial colure may therefore be traced by following the line connecting this star with the Pole Star.

Cancer. The space allotted to this group is rather small and there are no conspicuous stars. The characteristic figure is the cluster called Præsepe which may be found by passing from β Geminorum to α Leonis, the bright red star in that constellation. The cluster is a little south of this line. Two fourth magnitude stars flank this cluster on the east, and two more of similar brightness are readily found, the one north and the other southeast, the four making a curved line, convex towards Præsepe.

Leo. This fine constellation is easily traced. It has two characteristic figures,—the "Sickle" at the western and a right angled triangle at the eastern boundary of the area. The Sickle contains six bright stars, the group closely representing the shape of the article named. The bright red star at the end of the handle is α Leonis or Regulus. The Sickle is east of Cancer. East of the Sickle is the right-angled triangle, the easternmost star, β Leonis, having also the name Denebola. The figure of the lion is drawn with the Sickle for the forepart, the curve of the Sickle terminating in the head, and the triangle forms the hinderpart and tail of the animal. A number of faint stars south of the triangle represent the hind legs, the area, as shown on the chart, having a large southern extension.

North of the three zodiacal constellations are the two inconspicuous groups Lynx and Leo Minor. The eastern portion of Auriga is also north of Gemini and Ursa Major touches Leo on the northeast corner.

Lynx. This area is almost wholly destitute of stars visible to the naked eye, and is the name of the space between Auriga and Ursa Major. The head of the animal contains a number of stars near the limit of vision, north of the head of the Charioteer. The tail in the southeast of the area contains two stars easily noted, the southern of which, 40 Lyncis, is the brightest of the constellation. One of the fore paws of the Great Bear overlies the tail of the Lynx, and the two stars just named might with advantage have been included in Ursa Major, as mentioned in describing that constellation, and this overlapping thereby prevented.

Leo Minor. This group lies north of the Sickle and south of

the hind paws of the Great Bear, which were each marked, it will be remembered, by a pair of stars. An elongated triangle of fourth magnitude stars, numbered 21, 31 and 46 with a line of somewhat fainter stars south of them, numbered 30, 37 and 42 designates the characteristic figure. Or they may be traced by the guiding lines drawn on the chart.

Six constellations may be traced south of the zodiac by northern observers and a seventh is partly visible in the extreme south.

Monoceros. This is the name given to the space east of Orion north of the conspicuous group Canis Major and south of Gemini, Canis Minor and Hydra. The outlines of the area may be roughly determined by noting the positions of the five brightest stars, 11, 15, 22, 26 and 30, or the guide lines of the chart may be followed for a more minute study. The constellation was one of those added by Hevelius to name a space not already appropriated. All such constellations would necessarily be inconspicuous. The Unicorn is drawn with his head towards the northwest, at the star numbered 15.

Canis Minor. This group consists of two leading stars south of Castor and Pollux. They are quite like the latter pair in distance and might be confounded with them but for their marked difference in brightness, while Castor and Pollux are of nearly equal brilliancy. The brighter is α Canis Minoris or Procyon, one of the most brilliant stars in the sky, slightly preceding Sirius, the Dog Star, in its time of rising (as seen by northern observers), which is immortalized in the etymology of its name, the star preceding the Dog Star.

Hydra. This winding constellation is an interesting one to trace. The head is a group of stars south of Cancer and east of Leo Minor. From this several faint stars curve southward to the brighest star of the constellation, α Hydræ. Then a line of faint stars may be followed southward and eastward. The line runs south of Crater, into the third division of the heavens, south of Corvus and Virgo to the western boundary of Scorpio. On the chart this part of the heavens is drawn very much larger in proportion than the more northern constellations, which is a necessary but misleading feature of the planisphere projection. The constellation extends over about 100° in right ascension, which is about the distance between the Pleiades and the Sickle.

Sextans. This small area, the name of which was also assigned by Hevelius, lies between Hydra and Leo, and contains no conspicuous stars. The brightest star is of the fourth magnitude and is 12° directly south of Regulus.

Crater. This group lies south of the southern extension of Leo and north of Hydra. It is not difficult to trace a resemblance to a cup by following the guide lines of the chart. But the group must not be confounded with the much more conspicuous quadrilateral adjacent on the east, which is Corvus. The line of stars marking Hydra should also be traced first, when the relation of this group to the adjacent groups will be recognized.

Canis Major. This group, southeast of Orion is noteworthy because containing the brightest of the fixed stars, Sirius or α Canis Majoris. The characteristic figure is an elongated quadrilateral, formed by α and β, the latter of which is 5° west of the former, and δ and ε, southeast of this pair. The side α, δ, has an additional star o; beyond the quadrilateral, another bright star 10° west of ε, lettered ζ, marks the southwestern part of the area, while another star, η, forming an equilateral triangle with δ and ε marks the southeastern part.

Argo Navis. This constellation belongs to those southern groups, which are almost wholly below the horizon of observers in northern latitudes. The mast and stern of the ship, however, are in the region south of Hydra and east of Canis Major. As the constellation occupies an enormous area in the heavens, it is customary to subdivide it into smaller areas, like the counties of a state, which are named from the parts of the vessel. *Malus* and Puppis are the subdivisions in the region under discussion. The only stars easily visible however to observers in the United States are those in Puppis which are immediately adjacent to the southeastern part of Canis Major. A little group of inconspicuous stars is east of η Canis Majoris while 10° northeast is the only conspicuous star of the group, named ι Navis or φ Puppis. The latter designation is that given on the chart. Two conspicuous stars in this constellation may be seen to better advantage by observers in the southern part of the United States, than by those farther north. They are of the second magnitude and lettered ζ and γ respectively. The former is in the prolongation of the line from α Orionis to α Canis Majoris, and the latter 7° south of the former. Almost due south of Sirius is Canopus or α Argus, one of the most brilliant stars of the heavens, but as its declination is nearly 53° south, it cannot be seen by observers north of latitude 37°.

There are several points connected with the stars in this second division of the heavens which are worth noting:

It contains the brightest and the faintest of the stars which are called first magnitude stars. The division of the stars into

"magnitudes" is as old as the classical period of astronomy, and has come down to us from the Greeks, who used six classes into which the stars were graded according to their brightness. The word "magnitude" is evidently a misnomer, for the apparent brightness of a star depends upon its distance and its intrinsic brightness as well as upon its size, but the word is still retained as a synonym of apparent brightness. The classification was good for the second to the sixth magnitudes, but in the first grade all stars were included which are brighter than the limit between the first and second grade, and there is a wide range among the nineteen stars thus grouped. The photometric classification of stars follows the old one of magnitudes as far as is possible, but subdivides the first magnitude class into 1st magnitude, 0 magnitude, and as the scale runs out is obliged to call Canopus and Sirius of the -1 magnitude. There is a disagreement as yet as to the lower limit of the first magnitude group, some writers placing α Cygni or α Crucis in the list, and giving the number as 20 or 21. But α Leonis or Regulus is the one next brighter than the two named and may therefore be taken as the lower limit of brightness at present allowed without dispute for a first magnitude star. Any star in the sky which is between Sirius and Regulus in brilliancy is a first magnitude star. Fourteen of the nineteen are visible to northern observers. In the first division are Capella, Aldebaran, Betelgeuse and Rigel, or α Aurigæ, α Tauri, α Orionis and β Orionis respectively, and in the second division are Pollux, Regulus, Procyon and Sirius or β Geminorum, α Leonis, α Canis Minoris, and α Canis Majoris respectively.

The six first magnitude stars, Sirius, Procyon, Betelgeuse, Rigel, Aldebaran and Pollux are near enough in the sky to be grouped together. The first three named form a nearly equilateral triangle, to which Rigel may be added to form a quadrilateral, nearly square; or Pollux may be added to the three to form a diamond-shaped quadrilateral.

The zodiacal constellations of this division are those through which the Sun moves in summer, and hence are north of the equator. The leading stars of the groups are situated as follows regarding the ecliptic. *Gemini*: η is nearly at the solstitial point as above mentioned and Castor and Pollux are 7° and 12° respectively north of the ecliptic. The ancients adopted 8° as the width of the zodiac north and south of the ecliptic. The northern boundary of the zodiac therefore passes between these stars. *Cancer*: Præsepe is 2° north of the ecliptic. *Leo*: Regulus is a little north of the ecliptic.

The celestial equator, which passes very close to the western-most star of the belt of Orion, is 5° south of Procyon, and 7° south of the head of Hydra.

The constellations of the second division are best studied in the winter months, but can be well seen in the early spring also. At the first of April the meridian in the evening passes through Leo, and the constellations are for the most part in the west. If learned in this position they should be reviewed in the autumn when in the east in the evening sky.

The following table gives the approximate positions of the leading stars in each constellation.

APPROXIMATE POSITIONS OF THE LEADING STARS IN THE CONSTELLATIONS BETWEEN VI^h AND XII^h RIGHT ASCENSION, OMITTING CIRCUMPOLAR CONSTELLATIONS.

Name.	Magnitude.	Right Ascension. h m	Declination. ° ′
		LYNX.	
38	3.8	9 13	37 14
40	3.4	9 15	34 49
		LEO MINOR.	
		No bright stars.	
		GEMINI.	
η	3.5	6 9	22 32
μ	3.2	6 17	22 34
γ	2.0	6 32	16 29
ε	3.2	6 38	25 14
ξ	3.4	6 40	13 0
δ	3.6	7 14	22 10
α	2.0	7 28	32 7
β	1.1	7 39	28 16
		CANCER.	
ε (cluster).	—	8 34	19 58
		LEO.	
ε	3.1	9 40	24 15
μ	4.1	9 47	26 29
η	3.6	10 2	17 15
α	1.4	10 3	12 27
ζ	3.6	10 11	23 55
γ	2.2	10 14	20 21
δ	2.8	11 9	21 5
θ	3.5	11 9	15 55
β	2.2	11 44	15 8
		MONOCEROS.	
		No bright stars.	
		CANIS MINOR.	
β	3.1	7 22	8 30
α	0.5	7 34	5 29

SEXTANS.

No bright stars.

HYDRA.

Name.	Magnitude.	Right Ascension. h m	Declination. ° ′
ε	3.6	8 41	+ 6 47
ζ	3.3	8 50	+ 6 20
α	2.0	9 23	− 8 13
ν	3.3	10 45	− 15 40
γ	3.5	13 13	− 22 38

CRATER.

α	4.1	10 55	− 17 46
β	4.4	11 7	− 22 16
δ	3.9	11 14	− 14 14
γ	4.2	11 20	− 17 8
ζ	4.9	11 40	− 17 48

CANIS MAJOR.

ζ	3.0	6 16	− 30 1
β	2.0	6 18	− 17 54
α	− 1.4	6 41	− 16 34
ε	1.5	6 55	− 28 50
o^2	3.0	6 59	− 23 41
δ	1.8	7 4	− 26 12
η	2.4	7 20	− 29 6

ARGO NAVIS.

ξ	3.4	7 45	− 24 37
ζ	2.5	8 0	− 39 43
ν	2.9	8 3	− 24 1
γ	3.0	8 6	− 47 2

SUGGESTIONS TO AMATEURS.

Nebulæ and Clusters.

LEWIS SWIFT.

There are many varieties of nebulæ, as bright and faint, large and small, round, elliptical and irregular, etc., but they may be divided into two general classes, resolvable and irresolvable, or, what is still better, into stellar and gaseous nebulæ. But for the decisive revelations of the spectroscope, it would now, as in former times, be reasonable to infer that, inasmuch as many have been resolved into stars, all would be found thus resolvable if sufficient optical power were at our command. We find clusters of nebulæ as well as clusters of stars, the most wonderful series being the Magellanic Clouds of the southern hemisphere, not far distant from the pole. The most extensive group visible from our latitude is found in Virgo, where it often happens that

several are visible in a single field of the telescope. No one has ventured to suggest the reason for such a profusion in areas so small as these we have cited. It would seem that at some time, if not now, they were physically connected. This can scarcely be doubted of those so near together as to be in the same field of the telescope, but the most powerful telescopes fail to deal intelligently with them.

Leo, also, contains many nebulæ. With a field of 32′ on my 16-inch telescope, I have seen at one view nine conspicuous nebulæ, and Professor Burnham once saw, in another part of the sky, eighteen in a much smaller space. If eighteen stars of equal magnitude were found in such close proximity, they would certainly be pronounced a physically connected cluster.

In R. A. $16^h\ 1^m$, Dec. $+\ 18°$, there are twelve in one field of 32′ with one or two suspected ones, while just outside the field are eight others.

In a single field near Algol, I once counted twelve at one view.

There appears to be no relation whatever between the nebulæ and neighboring stars, and yet Sir William Herschel is reported as having bidden his sister when he encountered a vacancy or a region sparse in stars, to "Prepare to write, nebulæ are coming." The sky is filled with such vacancies, but it is contrary to my own experience to find that nebulæ are more numerous near these deserts, and the statement is so far from the truth that I must doubt his having uttered it.

Like many of the stars, some of the nebulæ are double and triple. One of my own, New General Catalogue, No. 6679, is a close double, suspected with a power of 132, confirmed with 200, and well separated with 250. I also found one of Sir William Herschel's to be an equally close double. It would be a great satisfaction to be fully assured that they are binaries.

Of clusters resolvable with such telescopes as amateurs possess, the sky affords numerous examples as the following list for A. D. 1900 will show:

No. 1. The Pleiades. On an exquisite night several years ago, I counted with my 4½-inch refractor three hundred stars in the cluster. On that occasion I first saw the Merope nebula which I strongly suspected to be a comet. Six hundred are visible with my 16-inch glass, but the celestial camera plainly depicts on the negative plate 2,326 stars.

No. 2. $2^h\ 15^m + 56°\ 39'$. This is the magnificent double cluster in Perseus, visible to the naked eye as a small, hazy spot between Cassiopeia and Alpha Persei.

No. 3. $8^h\ 34^m + 20°\ 20'$. This is the well known cluster visible to the naked eye as a small, round, hazy spot. It was first discovered or, at least, recorded by Hipparchus. It is number 44 of Messier's Catalogue, 1681 of Herschel's G. C., and 2652 of N. G. C. It is called Præsepe or the Beehive. It shows many little triangles, and is a very pretty object for small telescopes.

No. 4. $13^h\ 37^m + 28°\ 53'$. In the Hunting Dogs on a line with and nearly midway between Arcturus and Cor Caroli, a little nearer the former star. A grand cluster of one thousand stars of the eleventh magnitude. It is not visible to the naked eye. Sir William Herschel is made to say that it exhibited a mottled appearance to him which must certainly apply to some other object.

No. 5. $16^h\ 38^m + 36°\ 39'$. A gorgeous cluster through larger telescopes; one of the six visible to the unassisted eye. It is on a line between Eta and Zeta Herculis but nearer to Eta. It was discovered by Halley in 1714, and is number thirteen of Messier's Catalogue. Herschel, it is said, asserted that it contained 14,000 stars, a misprint no doubt for 4,000.

No. 6. $17^h\ 14^m + 43°\ 15'$. Also in Hercules, but the stars are fainter than in Messier 13. It is 92 of M. Cat. Its stars are from the eleventh to the eighteenth magnitudes.

No. 7. $18^h\ 12^m - 18°\ 29'$. A glorious field of stars in the Milky Way. This, with the 16-inch, is the most attractive object to visitors at the Observatory. The contrast between it and a black opening (coal sack) near by is very striking and elicits much comment. In this vacancy I see but three stars.

In $13^h\ 26^m + 47°\ 43'$ is the famous double nebula, 51 M., or the great spiral of Lord Rosse.

$17^h\ 59^m + 66°\ 38' =$ Gen. Cat. 4373; $19^h\ 42^m + 50°\ 17' =$ Gen. Cat. 4514; and $23^h\ 21^m + 42° =$ Gen. Cat., 4964, are the places of three bright planetary nebulæ. The second, one of the most interesting of nebulæ, has a very faint star exactly in its center, a severe test of vision. According to Professor Mitchell, "now you see it, and now you don't see it."

Mine differ from other eyes, if a blue color can be seen in any planetary nebula.

ROCHESTER, N. Y., Jan. 29, 1894.

To ask or search, I blame thee not, for heaven
Is as the book of God before thee set,
Wherein to read His wondrous works, and learn
His seasons, hours or days, or months, or years.

—Milton.

WHAT A FIVE-INCH TELESCOPE WILL SHOW.

GARRETT P. SERVISS.

In one of the early numbers of the *Sidereal Messenger*, Professor H. L. Smith, then of Hobart College, described the beautiful work done by a short focus telescope made for him by John Byrne of New York. The glass was of 4¼-inch aperture and 38-inch focal length. I had the pleasure of looking through that glass just after it had been finished by Mr. Byrne and before he had shipped it to its purchaser. It seemed to me then that I had never beheld such clean-cut star disks, and such admirable views of Saturn as it afforded.

Recently I have procured through Messrs. Gall and Lembke of New York, with whom Mr. Byrne is now associated, a short-focus 5-inch telescope of Byrne's making, and I think some account of its performances will be of interest to the readers of POPULAR ASTRONOMY. This telescope, of 5-inch clear aperture, has a focal length of 52½ inches. If made according to the ordinary formula it would have been about 75 inches in length. Two distinct advantages are gained through cutting down the focal length; first greater ease in handling, and second, increased light in proportion to length.

One of the first objects upon which I chanced to turn the glass last summer, after receiving it from the hands of the maker, was Antares. Everybody knows the story of the discovery by Professor Mitchell of the seventh magnitude green companion of this great fiery star. He saw it emerging before its brilliant comrade from occultation behind the Moon. It is not an easy star to see with telescopes of moderate size. Herschel missed it with his great instruments, and until 1844 nobody in Europe had ever seen it. I was gratified at the exceeding ease with which the 5-inch showed it. The disks of both stars were beautifully defined, and the diffraction rings playing around Antares added splendor to the contrast of color between it and its little companion. It was a most charming sight.

Wishing to try a closer test object, I turned to the star Σ 2173 in Ophiuchus. The components are each of sixth magnitude and their distance apart is 0″.91. This is just at the limit of separating power for a 5-inch according to Dawes' rule, and I might therefore have anticipated some difficulty. But I found none. The stars were split at once. The double ξ Scorpii, distance 1″.23, was so easily divided that I was able to show it to a person who had had no experience in using telescopes.

This winter I have tried the glass in Orion with equally gratifying success. In the presence of the Moon at first quarter I have seen both the fifth and the sixth stars in the trapezium almost without effort. The 1″ double, η Orionis, which Webb says was sometimes split by his 5½-inch, I can see completely separated at all times. The flocculent appearance of the great nebula as shown with this glass is a most interesting reminder of its appearance when viewed with the large telescopes of the observatories.

I have mentioned these particulars because I believe that it is a matter of interest, as well as of importance, to every amateur in astronomy to know what a really good glass of any given aperture should be able to do, and to know, moreover, who is competent to make good glasses. There are not so many men who can do it that there is any danger of their elbowing one another out of the field. Then, too, I wish to say a word in behalf of short-focus telescopes, especially for portable use. Nobody who has used a good short telescope will ever consent to be bothered with a long one of the same aperture.

BROOKLYN, N. Y., Jan. 17.

THE APEX OF THE EARTH'S WAY.

T. J. J. SEE.

The annual motion of the Earth westward round the Sun gives rise to the apparent eastward motion of the Sun among the stars, which is easily observed by noting the changing position of the Sun among the constellations lying near the ecliptic. In this way the path of the Sun among the stars was investigated by the ancients, who called the great circle which the Sun annually traces out in the sky, the *ecliptic*, because the eclipses, which depend upon the positions of the Sun and Moon with respect to the Earth (as was fully understood by the ancients) occur near this apparent path of the Sun, which is the intersection of the plane of the Earth's orbit with the celestial sphere.

Now, if we look at the Sun at noon, we know that it is apparently moving eastward, and that the Earth is really moving westward, in the plane of the ecliptic in a direction perpendicular to the line drawn from the observer to the Sun. The apex of the Earth's way at noon will, therefore, generally be near the western horizon, at a point in the ecliptic 90° from the Sun. The

direction from which the Earth is moving will be situated at a point in the ecliptic 90° ahead of the Sun, and at noon will therefore be near the eastern horizon. Now when the Sun is setting the point from which the Earth is receding will be near the meridian, and the apex of the Earth's way will be under the Earth, the two points being 180° apart, on exactly opposite sides of the celestial sphere. At midnight, when the Sun is at its lower culmination, the apex of the Earth's way will be rising, while the point of the heavens from which the Earth is receding will be setting. If, therefore, we know the path of the ecliptic by the positions of naked-eye stars, we shall be able to locate the apex of the Earth's way at any given time of the year. Owing to the motion of the Earth, the position of this apex will move eastward along the ecliptic at the rate of about a degree per day, the same rate as the Sun moves. The point from which the Earth is moving advances at the same rate, and if we can locate the apex of the Earth's way, it will be easy to locate the point of the heavens from which the Earth is moving. In observing shooting stars it is often important to be able to locate the apex of the Earth's way by means of naked-eye stars, as it is the point from which most meteors will generally appear to come, owing to the motion of the Earth being here added to the independent motion of the meteorites in space. By the use of star charts, or a celestial globe, this is easily effected. If we begin with January the apex of the Earth's way, for the twelve months of the year, is situated successively in the following constellations:

Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces, Aries, Taurus, Gemini, Cancer, Leo.

Any amateur who is familiar with the constellations along the ecliptic can therefore easily locate the apex of the Earth's way at any time, and it is thus easy in contemplating the heavens to look back on the path we have traversed in our journey round the Sun, and to locate the apex of the Earth's way towards which we are moving at the rate of about 19 miles per second.

THE UNIVERSITY OF CHICAGO, 1894, Jan. 25.

Brilliant Meteor.—At about 8:30 last evening, March 2, a bright meteor swept across the southern sky, meeting the meridian at about an angle of 80°, moving westward and a little southward. It passed about 1° south of Sirius, and its path seemed to be about 15° long. The first half or two-thirds of the track showed many sparks, while the last of it was very distinctly blue and was very bright and without sparks. Moreover, this portion seemed to be of an extremely elongated spindle shape, tapering slightly towards the ends, and there being cut off cleanly. The track disappeared instantly, and did not extend farther west than the star in the nose of Canis Major. W. S. A.

PLANET NOTES FOR MAY.

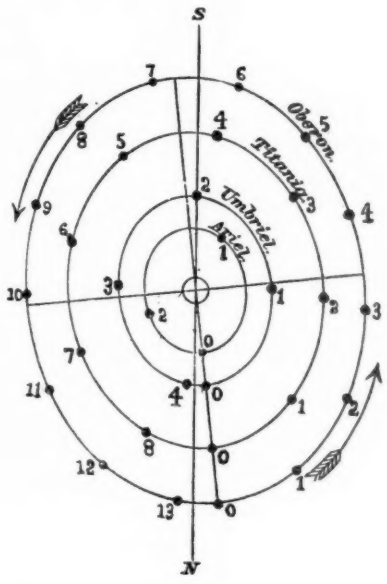
H. C. WILSON.

Mercury will be at superior conjunction, *i. e.*, behind the Sun, May 20 at 9^h 44^m central time. During May this planet will be wholly hidden to the eye by the glare of the Sun, although it is calculated to reach its greatest brilliancy on the 23d.

Venus will be in good position for observation about 4 o'clock in the morning during May. Her phase will increase from about half to two-thirds during the month, while her brilliancy will diminish in the ratio of 137 to 97 in the same time, because of her recession from the Earth. Venus and the waning Moon will be in conjunction May 1st at 5^h 07^m P. M. central time and again May 31 at 3^h P. M.

Mars is also to be observed in the morning. He is about 30° west and 14° south from Venus, in the constellation Capricorn and will move northeast into Aquarius during May. At the end of the month he will be found about half way between the first magnitude stars Fomalhaut (*α Piscis Austrini*) and Markab (*α Pegasi*). Mars will be in conjunction with the Moon March 28 at 2^h 18^m central time. Observers in Central and South America may see the planet occulted at this time.

Jupiter and *Neptune* will be too low in the west during the early evening hours for any satisfactory observations during this month. The tables of the satellites are therefore omitted. On Poole Bros. map for this month, however, the courses of Jupiter and Neptune among the stars are indicated for the six months from April 1 to Sept. 1.



APPARENT ORBITS OF THE SATELLITES OF URANUS IN 1894.

Saturn will be in best position for observation during May, crossing the meridian about 10 o'clock in the first half and 9 o'clock P. M. in the latter half of the month. The rings of Saturn are now pretty well widened out, so that the three parts can be distinguished readily and the Cassini division can be followed all the way around. The elevation of the Earth above the plane of the rings is about 12°. Saturn is in the constellation Virgo about 5° north of the first magnitude star Spica, with which he is almost equal in brightness. A conjunction of the Moon and Saturn occurs May 16 at 10^h 55^m A.M.

Uranus is also in good position for observation, being at opposition May 3. We give this time a diagram showing the apparent courses of the four satellites about the planet. In the tables we give the times when each satellite will be at greatest elongation, that is, at the point 0 on the diagram. The black dots with the numerals beside them indicate the positions of the satellites on the successive dates after the northern elongation. For example, Umbriel will be at northern elongation, *i. e.*, at the point marked 0 on its orbit, May 3 at $8^h.6$ P. M. On May 4 at the same hour it will be at the point marked 1, May 5 at the same hour it will be at 2, etc.

The four oldest of the minor planets, *Ceres*, *Pallas*, *Juno* and *Vesta*, all happen to be in the region of sky covered this month by Poole Bros'. map, and their apparent courses for the next six months are shown in red upon the map. Ceres, Pallas and Vesta have passed the best time for their observation but will all be bright enough to be found without much difficulty during the next three months. Ceres was at opposition March 13. Its brightness will be equal to that of a star of the 7.2 magnitude April 1, 7.5^m May 1, 7.9^m June 1, 8.2^m July 1, 8.5^m August 1, and 8.8^m September 1. Pallas was at opposition Feb. 7. Its brightness will be 7.0^m April 1, 7.6^m May 1, 8.1^m June 1, 8.5^m July 1, 8.8^m Aug. 1, and 9.1^m Sept. 1. Vesta was at opposition March 10. Its brightness will be 6.5^m April 1, 6.8^m May 1, 7.2^m June 1, 7.5^m July 1, 7.8^m Aug. 1 and 7.9^m Sept. 1. Juno is not so favorably situated. Although she comes to opposition May 7 she is so far from her perihelion, or point of nearest approach to the Sun, that she will at brightest be only of the tenth magnitude and will therefore probably not be seen by the amateur.

Planet Tables for May.

[The times given are local time for Northfield. To obtain Standard Times for Places in approximately the same latitude, add the difference between Standard and Local Time if west of the Standard Meridian or subtract if east].

Date. 1894.	R. A. h m	Decl. ° ′	Rises. h m	Transits h m	Sets. h m
		MERCURY.			
May 5.....	1 50.6	+ 9 16	4 15 A. M.	10 56.5 A. M.	5 38 P. M.
15.....	3 06.3	+ 16 58	4 18 "	11 32.7 "	6 47 "
25.....	4 35.7	+ 23 14	4 27 "	12 22.5 P. M.	8 08 "
		VENUS.			
May 5.....	23 58.4	− 1 15	3 05 A. M.	9 04.5 A. M.	3 04 P. M.
15.....	0 37.7	+ 2 17	2 51 "	9 04.4 "	3 18 "
25.....	1 18.2	+ 6 03	2 37 "	9 05.4 "	3 34 "
		MARS.			
May 5.....	21 58.9	− 14 11	1 58 A. M.	7 05.3 A. M.	12 12 P. M.
15.....	22 26.0	− 11 55	1 36 "	6 53.1 "	12 10 "
25.....	22 52.4	− 9 32	1 14 "	6 40.2 "	12 07 "
		JUPITER.			
May 5.....	4 21.2	+ 20 59	5 53 A. M.	1 26.5 P. M.	9 00 P. M.
15.....	4 30.8	+ 21 22	5 22 "	12 56.8 "	8 32 "
25.....	4 40.6	+ 21 43	4 50 "	12 27.2 "	8 04 "
		SATURN.			
May 5.....	13 18.2	− 5 18	4 39 P. M.	10 22.1 P. M.	4 06 A. M.
15.....	13 15.9	− 5 05	3 56 "	9 40.5 "	3 25 "
25.....	13 14.1	− 4 56	3 14 "	8 59.4 "	2 44 "
		URANUS.			
May 5.....	14 43.6	− 15 25	6 45 P. M.	11 47.2 P. M.	4 49 A. M.
15.....	14 41.9	− 15 18	6 04 "	11 06.3 "	4 09 "
25.....	14 40.4	− 15 11	5 22 "	10 25.4 "	3 28 "

NEPTUNE.

Date. 1894.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 5.....	4 43.6	+ 20 50	6 16 A. M.	1 49.1 P. M.	9 22 P. M.
15.....	4 45.2	+ 20 52	5 38 "	1 11.2 "	8 44 "
25.....	4 46.7	+ 20 55	5 00 "	12 33.4 "	8 07 "

THE SUN.

May 5.....	2 51.0	+ 16 24	4 44 A. M.	11 56.5 A. M.	7 08 P. M.
15.....	3 30.0	+ 18 59	4 32 "	11 56.2 "	7 20 "
25.....	4 10.0	+ 21 03	4 23 "	11 56.7 "	7 31 "

THE MOON.

May 2.....	0 16.4	+ 1 02	3 24 A. M.	9 34.2 A. M.	3 56 P. M.
4.....	1 58.0	+ 14 11	3 59 "	11 07.7 "	6 34 "
6.....	3 56.9	+ 24 38	4 58 "	12 58.5 P. M.	9 12 "
8.....	6 13.3	+ 28 33	6 30 "	3 06.6 "	11 36 "
10.....	8 27.0	+ 24 03	9 01 "	5 12.0 "	1 08 A. M.
12.....	10 21.9	+ 13 34	11 41 "	6 58.8 "	2 01 "
14.....	12 02.0	+ 0 43	2 09 P. M.	8 30.7 "	2 38 "
16.....	13 37.8	− 11 49	4 30 "	9 58.4 "	3 15 "
18.....	15 18.4	− 21 56	6 50 "	11 30.9 "	4 03 "
20.....	17 07.4	− 27 42	9 05 "	1 11.6 A. M.	5 15 "
22.....	18 59.6	− 27 51	10 53 "	2 55.8 "	7 01 "
25.....	20 45.6	− 22 38	12 05 A. M.	4 33.6 "	9 10 "
27.....	22 22.0	− 13 24	12 52 "	6 02.1 "	11 23 "
29.....	23 54.3	− 1 36	1 28 "	7 26.2 "	1 38 P. M.
31.....	1 31.8	+ 11 11	2 04 "	8 55.4 "	4 03 "

Phases and Aspects of the Moon.

Central Time.

	d	h	m	
New Moon	May 5	8	42	A. M.
Perigee	" 7	10	24	P. M.
First Quarter	" 12	12	21	A. M.
Full Moon	" 19	10	43	A. M.
Apogee	" 23	6	20	P. M.
Last Quarter	" 27	2	04	P. M.

Elongations of the Satellites of Uranus.

[The diagram shows the apparent form of the satellites of Uranus during the summer of 1894. The black dots with the numerals indicate the positions of the satellites at intervals of 1 day after each northern elongation. The points marked 0 are those of northern elongation.]

ARIEL.

	h		
May 3	11.2 A. M.	N	
5	11.7 P. M.	N	
8	12.2 P. M.	N	
11	12.7 A. M.	N	
13	1.2 P. M.	N	
16	1.7 A. M.	N	
18	2.1 P. M.	N	
21	2.6 A. M.	N	
23	3.1 P. M.	N	
26	3.5 A. M.	N	
28	4.0 P. M.	N	
31	4.5 A. M.	N	

UMBRIEL.

	h		
May 3	8.6 P. M.	N	
8	12.1 A. M.	N	
12	3.5 "	N	
16	7.0 "	N	
20	10.5 "	N	
24	2.0 P. M.	N	
28	5.4 "	N	

TITANIA.

	h		
May 2	7.8 P. M.	S	
7	4.3 A. M.	N	

TITANIA Cont.

	h		
May 11	12.8 P. M.	S	
15	9.3 "	N	
20	5.8 A. M.	S	
24	2.3 P. M.	N	
28	10.8 "	S	

OBERON.

	h		
May 7	9.8 A. M.	S	
14	3.4 "	N	
20	9.0 P. M.	S	
27	2.7 "	N	

Elongations of the Satellites of Saturn.

MIMAS.

		h		
May	1	9.9	P. M.	W
	2	8.5	"	W
	3	7.1	"	W
	4	5.7	"	W
	5	4.3	"	W
	6	2.9	"	W
	8	12.9	A. M.	E
	8	11.5	P. M.	E
	9	10.1	"	E
	10	8.8	"	E
	11	7.4	"	E
	12	6.0	"	E
	13	4.6	"	E
	14	3.2	"	E
	16	1.2	A. M.	W
	16	11.8	P. M.	W
	17	10.4	"	W
	18	9.0	"	W
	19	7.6	"	W
	20	6.2	"	W
	21	4.8	"	W
	22	3.4	"	W
	24	1.4	A. M.	E
	24	12.0	midn.	E
	25	10.6	P. M.	E
	26	9.3	"	E
	27	7.9	"	E
	28	6.5	"	E
	29	5.1	"	E
	30	3.7	"	E

ENCELADUS.

		h		
May	2	3.6	P. M.	E
	4	12.5	A. M.	E
	5	9.4	"	E
	6	6.3	P. M.	E
	8	3.1	A. M.	E
	9	12.0	M.	E

ENCELADUS Cont.

		h		
May	10	8.9	P. M.	E
	12	5.8	A. M.	E
	13	2.7	P. M.	E
	14	11.5	"	E
	16	8.4	A. M.	E
	17	5.3	P. M.	E
	19	2.2	A. M.	E
	20	11.1	"	E
	21	7.9	P. M.	E
	23	4.8	A. M.	E
	24	1.7	P. M.	E
	25	10.6	"	E
	27	7.5	A. M.	E
	28	4.3	P. M.	E
	30	1.2	A. M.	E
	31	10.1	A. M.	E

TETHYS.

		h		
May	1	9.4	P. M.	E
	3	6.7	"	E
	5	4.0	"	E
	7	1.3	"	E
	9	10.6	A. M.	E
	11	7.9	"	E
	13	5.2	"	E
	15	2.5	"	E
	16	11.8	P. M.	E
	18	9.1	"	E
	20	6.4	"	E
	22	3.7	"	E
	24	1.0	"	E
	26	10.3	A. M.	E
	28	7.6	"	E
	30	4.9	"	E

DIONE.

		h		
May	2	10.3	P. M.	E
	5	4.0	"	E
	8	9.7	A. M.	E

DIONE Cont.

		h		
May	11	3.4	A. M.	E
	13	9.0	P. M.	E
	16	2.7	"	E
	19	8.4	A. M.	E
	22	2.0	"	E
	24	7.7	P. M.	E
	27	1.4	"	E
	30	7.1	A. M.	E

RHEA.

		h		
May	4	3.3	P. M.	E
	9	3.6	A. M.	E
	13	4.0	P. M.	E
	18	4.4	A. M.	E
	22	4.8	P. M.	E
	27	5.2	A. M.	E
	31	5.5	P. M.	E

TITAN.

		h		
May	2	11.9	P. M.	I
	7	3.0	A. M.	W
	11	5.2	"	S
	14	11.8	P. M.	E
	18	9.4	"	I
	23	12.3	A. M.	W
	27	2.7	"	S
	30	9.3	P. M.	E

HYPERION.

		h		
May	3	10.8	P. M.	W
	8	8.3	A. M.	S
	13	1.0	P. M.	E
	19	8.7	"	I
	25	3.4	A. M.	W
	29	12.8	P. M.	S

IAPETUS.

		h		
Apr.	27	9.2	A. M.	I
May	17	4.3	"	W
June	6	3.7	"	S

Maxima and Minima of Variable Stars.

		Maxima		Minima
May	2	R Trianguli	May 1	T Ursæ Maj.
	3	S Carini	1	T Libræ
	3	U Monocerotis	1	R Scuti
	4	R Lyræ	3	Y Virginis
	6	U Aurigæ	10	η Geminorum
	7	V Ophiuchi	16	S Orionis
	10	V Virginis	18	S Leonis
	11	S Virginis	18	R Camelopardi
	13	R Tauri	21	W Cygni
	17	U Geminorum	22	V Tauri
	18	S Serpentis	22	R Serpentis
	19	T Pegasi	22	R Sagittæ
	91	S Vulpeculæ	29	R Ceti
	20	S Aquilæ	30	U Monocerotis
	21	T Herculis		
	24	T Cassiopeiæ		
	27	R Aurigæ		
	29	W Tauri		
	31	S Hydræ		
	31	S Piscis Austrini		

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Central Standard Time.]

U CEPHEI.

May	2	2 A. M.
	4	2 P. M.
	7	2 A. M.
	9	2 P. M.
	12	2 A. M.
	14	2 P. M.
	17	1 A. M.
	19	1 P. M.
	22	1 A. M.
	24	1 P. M.
	27	1 A. M.
	29	1 P. M.

R CANIS MAJORIS.

May	1	3 A. M.
	2	6 "
	3	10 "
	4	1 P. M.
	5	4 "
	6	7 "
	7	11 "
	9	2 A. M.
	10	5 "
	11	8 "
	12	12 M.
	13	3 P. M.
	14	6 "
	15	9 "
	17	1 A. M.
	18	4 "
	19	7 "
	20	10 "
	21	2 P. M.
	22	5 "
	23	8 "
	24	11 "
	26	3 A. M.
	27	6 "
	28	9 "
	29	12 M.
	30	4 P. M.
	31	7 "

S CANCRI.

May	2	11 A. M.
	11	11 P. M.
	21	10 A. M.
	30	10 P. M.

S ANTLIÆ.

(Every third minimum.)

May	1	8 A. M.
	2	7 "
	3	7 "
	4	6 "

S ANTLIÆ Cont.

May	5	5 A. M.
	6	5 "
	7	4 "
	8	3 "
	9	3 "
	10	2 "
	11	1 "
	12	1 "
	12	12 midn.
	13	11 P. M.
	14	11 "
	15	10 "
	16	9 "
	17	9 "
	18	8 "
	19	7 "
	20	7 "
	21	6 "
	22	5 "
	23	5 "
	24	4 "
	25	3 "
	26	3 "
	27	2 "
	28	1 "
	29	1 "
	30	12 M.
	31	11 A. M.

δ LIBRÆ.

May	3	1 A. M.
	5	9 "
	7	5 P. M.
	10	1 A. M.
	12	9 "
	14	5 P. M.
	16	12 midn.
	19	8 A. M.
	21	4 P. M.
	23	12 midn.
	26	8 A. M.
	28	4 P. M.
	30	12 midn.

U CORONÆ.

May	1	6 P. M.
	5	5 A. M.
	8	3 P. M.
	12	2 A. M.
	15	1 P. M.
	18	12 midn.
	22	11 A. M.
	25	10 P. M.
	29	8 A. M.

U OPHIUCHI.

May	1	1 P. M.
	2	9 A. M.

U OPHIUCHI Cont.

May	3	5 A. M.
	4	1 "
	4	9 P. M.
	5	5 "
	6	1 "
	7	9 A. M.
	8	6 "
	9	2 "
	9	10 P. M.
	10	6 "
	11	2 "
	12	10 A. M.
	13	6 "
	14	2 "
	14	11 P. M.
	15	7 "
	16	3 "
	17	11 A. M.
	18	7 "
	19	3 "
	19	11 P. M.
	20	7 "
	21	4 "
	22	12 M.
	23	8 A. M.
	24	4 "
	24	12 midn.
	25	8 P. M.
	26	4 "
	27	12 M.
	28	9 A. M.
	29	5 "
	30	1 "
	30	9 P. M.
	31	5 "

Y CYGNI.

May	1	12 M.
	2	12 midn.
	4	12 M.
	5	12 midn.
	7	12 M.
	8	12 midn.
	10	12 M.
	11	12 midn.
	13	12 M.
	14	12 midn.
	16	12 M.
	17	12 midn.
	19	12 M.
	20	12 midn.
	22	12 M.
	23	12 midn.
	25	12 M.
	26	12 midn.
	28	12 M.
	29	12 midn.
	31	12 M.

PRACTICAL SUGGESTIONS.

26. What preparation in Mathematics and Mechanics is necessary for the study of Chauvenet's Practical and Spherical Astronomy?

Answer: This query may best be answered by referring to the work done in graduate courses in mathematics and astronomy at Goodsell Observatory of Carleton College. Graduate students only have attempted this work, and those who have had a good training in the elements of the calculus and college physics have advanced with greater rapidity. The student should have a preparation in trigonometry equal to that given by Chauvenet; in analytic geometry, that of Howison or Smith, including three dimensions; the differential and integral calculus complete, as given by Hardy, or equivalent; thorough work, by laboratory methods in light, heat, sound, electricity, magnetism; and analytic mechanics equivalent to that given by Wood. This schedule embraces nearly a year of work for a graduate student before he is ready to undertake Chauvenet's practical and theoretical astronomy and expect to read from fifteen to thirty pages a day and do all the work faithfully that is indicated in the text. In our practice, it has seemed best when we came to the illustrative examples under any topic, not only to perform those given, but also to offer other simple ones that would require the use of the astronomical instruments to obtain the necessary data, thereby giving the student practice with the instruments in connection with the application of important mathematical formulæ. In connection with other study the two volumes of Chauvenet's practical and spherical astronomy are pursued 47 weeks continuously in the special course above referred to.

27. Was Mercury visible to the naked eye during the last days of February?

E. E. M.

Answer: It was. The bright object referred to in the letter of the above querist was Mercury.

28. Will you suggest a suitable glass adapted to the use of beginners already having a field glass? It is wanted for occasional use and moderate power only is expected.

W. R.

Answer: It is difficult to answer the above query definitely and briefly, because so much that is useful may be done with small instruments, if they are only adapted in unimportant particulars to the special lines desired. A telescope of 3 or 4 inches aperture if properly mounted will give a wide range of visual observation. It is of the first importance that the mounting be heavy enough to hold the telescope steadily. If the mounting be portable, (as is usual with such a size of glass) it must be heavy enough for out-of-door use when the wind blows moderately to prevent unsteadiness, which is a common and a serious fault with small telescopes.

If the observer wishes only to look at celestial objects for the purpose of satisfying himself as to their casual appearance in the telescope, and nothing more, then a battery of eye-pieces adapted to the size of the glass is all that is necessary. If he wishes to do some study of any particular class of objects, then his instrument should be conveniently adapted to the special line of his choice. This suggestion is quite important. The student or observer who uses a telescope without any method or aim will soon tire of it, for that reason. But if he has some object before him to work out carefully and in a methodical way, he will never lack interest in it if he has wisely chosen his theme. That is the way Burnham, Barnard, Dawes, Swift and a multitude of others have worked, and become

famous without, at all, seeking notoriety, but rather industriously laboring to master the details of everything they wanted to know, so that when any given piece of work was done there was a belief that the best was done that could be accomplished under the circumstances. This is the only way to gain confidence, and, every one knows that such methods of acquiring skill are not peculiar to the study of astronomy alone. What is worth doing at all is worth doing well. This partial answer may be used in directing thought somewhat in regard to first things in answering this broad query.

29. Are large observatories heated in winter? If so, how are the currents overcome? C. F. H.

Answer: The observing room should be kept at the same temperature as the outside, as nearly as possible, to avoid currents of air of varying temperature which will affect the "seeing" unfavorably. Even the radiation of the walls of the Observatory in rooms without fire make it almost impossible to keep the inside temperature the same as that outside. In good observing rooms it is likely to vary 2° or 3° one way or the other.

30. Will the same eye-pieces made for a 3-inch objective do for a 6-inch? C. F. H.

Answer: Yes.

31. What do astronomers think of that Chicago man's idea of building large objectives in sections? Has it ever been tried before? C. F. H.

Answer: We have not heard that any astronomer or physicist has expressed an opinion at all in regard to the so-called discovery of Mr. Gotham of Chicago. For ourselves we have not thought it worth while to inquire about the matter further than the casual reading of the reports that appeared about the 10th of last month in Chicago and New York daily papers. The proof of the claim will be accepted when a single good telescope on that plan is made by any one.

32. How is it that astronomers differ so widely in the estimates of the distances of the stars obtained by parallax? F. A. S.

Answer: For fuller answer to this query than space will here allow the reader is asked to consult the November number of this publication which contains an article titled "The Distance of the Stars," (page 129), and the frontispiece of the same number which was designed especially to show the degree of accuracy possible to this kind of astronomical work. The main reasons why our best knowledge of such data is apparently so discordant are there set forth.

33. If the Sun's equator inclines to the plane of the ecliptic 7° 15′, and the north pole of the Sun leans in the direction of the position of the Earth in its orbit on Sept. 13, what would be the angle between the Sun's equator and that of the Earth? How is the problem solved? Toward what place in the heavens would the solar axis point? Give right ascension and declination. J. D. D.

Answer: Professor Young, in his book, "The Sun," p. 139, gives the right ascension of the north pole of the Sun as $18^h\ 44^m$ and its declination as 65°. The axis of the Sun is directed toward a point in the constellation of Draco, not marked by any conspicuous star. This point is almost exactly half way between the bright star α Lyræ and the polar star.

As to the process by which the inclination of the Sun's equator to that of the Earth is determined, from data given as indicated in the query, it is simply the solution of a spherical triangle by the ordinary rules of trigonometry. Imagine a great sphere surrounding the Sun. The axes of the equator, the ecliptic and

the Sun extended to the north will cut this sphere in three points which we will designate A, B and C in the order named. These three points form the vertices of a spherical triangle of which the sides AB and BC are known, the former being the distance between the poles of the ecliptic and equator or the ***obliquity of the ecliptic***, 23° 27′, the latter the inclination of the Sun's equator to the plane of the ecliptic, 7° 15′. The third side AC is the desired inclination of the Sun's equator to the celestial equator. We know also the angle at B, which is 180° — the longitude of the point where the Sun's equator crosses the ecliptic. The last mentioned longitude is now about 74° 20′. Knowing the two sides and the included angle of the spherical triangle, the other parts may be easily found.

One can determine these roughly by measurement upon a large globe. Draw a great circle on the globe and take any point A as the north pole of the celestial equator. From A measure off 23½° to B, the pole of the ecliptic. At B construct the angle 106½°, counting around from A in the direction of movement of the hands of a watch, and measure off an arc of 7¼° to C, the north pole of the Sun. The arc AC may then be measured, giving the inclination of the solar equator to the celestial equator, which is also 90° — the declination of the solar axis. Measure the angle between the arcs AB and AC and add 270°. This will give the right ascension of the solar axis.

GENERAL NOTES.

Subscribers sometimes suggest themes for information that have so wide a range, as to require the preparation of an article to make the meaning sought entirely clear. Such queries may take more time to answer them promptly than we have at command. Under such circumstances we often apply to our friends to help us. Such a case occurred a few days ago. A scholarly reader asked information about the apex of the Earth's Way, and we requested Professor T. J. J. See of the University of Chicago to prepare a brief article on that topic that would explain all in plain language. He has done so, and the excellent statement will be found elsewhere in this issue. We ought to say for Professor See that this writing was done because we asked it, and because he was kindly willing to help popular readers to find out what they wanted to know. No one who knows the elements of astronomy will suppose, we are sure, that Professor See's intention was to give an original paper on that theme.

Naked-Eye Sunspots.—Mr. Morris Peck of Red Bank, O. in a recent letter gives an account and drawing of a large sunspot seen Feb. 22. By the aid of a field-glass three spots could be seen, one of them was visible to the naked eye on each of the two days. It was not visible March 1.

This great spot was first seen and photographed at Goodsell Observatory of Carleton College on Feb. 15, when it was just visible on the east limb of the Sun. It was also photographed on the 16, 17, 21, 22, 23, 24, 26, 27. In comparing Mr. Peck's drawing with our photographs there is no doubt but that he has drawn the some spot that we photographed. We were also interested in the Greenwich observations of this sunspot. It was there seen and measured February 18. It was then 1900 millionths of the solar hemisphere, and the ***Observatory*** gives the following in regard to magnetic disturbance during the life of the spot: "A considerable magnetic disturbance was observed to begin very sharply

at $8^h\ 15^m$ P. M. on Feb. 20, and the movements continued to be pretty active till 11^h P. M. on Feb. 21. The magnets remained fairly quiescent for 24 hours, when the disturbance recommenced with greater intensity than before, continuing until 2^h A. M. on the 26th with another quiescent period between 7^h A. M. on Feb. 24 to 7^h A. M. Feb. 25."

Minor Planets.—Since our last issue we have to record the discovery of four new minor planets. as follows:

A. T. Jan. 29, Charlois, Nice.
A. U. Jan. 29, Charlois, Nice.
A. V. Feb. 16, Courty, Bordeaux.
A. W. Feb. 18, Wilson, Northfield.

In the March number of this publication an account of the photographic discovery of the last named planet was given by Dr. Wilson. In the March number of *Astronomy and Astro-Physics* a fuller account will also be found. It is an interesting fact that the planet had passed opposition about four months at the time of discovery, and was then probably a little less than the 12 magnitude. At opposition it would of course be somewhat brighter.

From the last *Observatory* we learn that "the following six planets, all discovered by M. Charlois in 1893, have received permanent numbers: AJ = (373), AK = (374), AL = (375), AM = (376), AN = (377), AP = (378). AO does not receive a permanent number, not having been sufficiently observed."

Celestial Motions, A Handy Book of Astronomy, by William Thynne Lynn, appears in its eighth edition under date of Feb. 1, 1894. This is an attractive little Fcap octavo of 125 pages. It contains eleven chapters on the following subjects:—The Earth, The Moon, The Sun, The Solar System, The Planets, Comets, Meteoroids, The Fixed Stars, The Constellations, The Refraction, Propagation and Aberration of Light, The Calendar. It is illustrated by the following plates: Comparative Sizes of the Sun and Principal Planets, Diagram illustrating the Motions of the November Meteors, Diagram illustrating the Relative Positions of the Seven Principal Stars of Ursa Major. The above contents fairly represent the scope of this book which gives in compact form much valuable information on the subjects treated. This edition differs from those which have preceded it, in that additional matter is introduced in the chapter on the fixed stars, and some details on periodic comets are omitted. A few pages at the close of the book are given to the explanation of technical terms. Publisher, Edward Stanford, 26 & 27 Cockspur St., London, S. W. Price 2s.

Remarkable Comets, by the same author as the above, is an Fcap octavo of 40 pages. This is a very readable book and is valuable for reference. It treats of "those comets which may be considered remarkable either for their brilliant appearance, their periodic returns or any other circumstance respecting them." Beginning with the comet recorded by Aristotle which appeared when he was about thirteen years of age, the writer names and briefly states interesting details in regard to the best known comets to the present time. Incidentally and without burdening the text, remarkable historic events which were coincident with the appearance of comets are mentioned. There is also presented a condensed history of the progress made in the knowledge of cometary motion and character. The book closes with "a list of the dates in order of the next returns of the comets which may fairly be expected to reappear." Publisher Edward Stanford. Price 6d.

Celestial Objects for Common Telescopes.—This well known book by the Rev. T. W. Webb has already reached its fifth edition. Its fourth edition was published in 1881, in one volume, containing 493 pages of excellent matter conveniently arranged for reference, and in every respect well adapted to supply the place it was intended to fill. When the edition became exhausted, the friends of the work considered what should be done to bring it to date and to the present wants of Amateur Astronomy. The preparation of the fifth edition was undertaken by Rev. T. E. Espin, and it was decided to bring out the same in two volumes instead of one with Messrs. Longmans, Green & Co. of London and New York, as publishers. The first volume has been issued and it is before us. It has nearly the same appearance as formerly, the type essentially the same and the size of the page the same, although its shape is slightly different. It has been the purpose of the reviser to make as little change in the text as possible, omitting, or adding new matter, when really necessary to make the new edition what the present state of science demands The first 18 pages are almost identical with those of the fourth edition. Then follow lengthy notes on celestial photography and the spectroscope as applied to the telescope. Part II, The Solar System is taken up in the same order as before. To the Sun is given a little less space than before, although a number of new notes are furnished by Miss Brown who has been asked to contribute for this topic. The planets Mercury and Venus have about the usual space with notes concerning late work on the rotation periods of each, although we notice that the weight of authority is claimed for the 24 hour period for the latter planet, instead of that advocated by Schiaparelli. Terby's work is later, but is it more exhaustive ar decisive?

A few pages have been added to the matter given concerning the Moon. Mr. Elger, who has been consulted in this part of the revision, thinks that if the matter were to be brought to date many alterations and insertions in the text would be necessary. He has given a good note (on page 79) of Professor Pickering's work at Arequipa on the streaks around Tycho with the 13-inch telescope. We do not notice any reference to the study of the varying temperature of the Moon's surface as related to its phase which has been recently shown by the aid of the bolometer at the Allegheny Observatory.

In the notes on Mars reference is made to the so-called "canals," as observed in 1881–2 and since, and Professor W. H. Pickering's observations of as many as 40 lakes at the intersection of the "canals," and the evidence of the peculiar seasons on the planet as derived from the markings of the planet's surface. The narrow, dark zone surrounding the south polar spot, as seen by several observers in 1892, is also noticed. Its deep shade, its wonderful changes indicating a process of violent dissolution on the one hand, and on the other a change of size in the brief time of 24 hours affecting an area as great as 2,500,000 square miles that had the appearance of a fall of snow; also the dark line across the north polar cap and its divisions as seen in 1888 by several observers.

The new matter for Jupiter is supplied by Rev. W. R. Waugh, and in all consists of about four pages, having reference mainly to later studies of the surface markings of the planet and the fifth satellite by Barnard. Saturn, Uranus and Neptune are without important new notes. About three pages are added to the subject of comets, and Mr. Denning has supplied about nine pages pertaining to meteors which is new matter and of course important. Two general appendices follow which give brief additions to subjects already considered. This revision seems to be excellently done.

PUBLISHERS' NOTICES.

Subscribers will please bear in mind that names and addresses should *always* be plainly written. During last month two orders have been returned because they were uncertain.

All drawings should be made in India Ink, and twice the size intended for the printed page, thereby giving better results when reduced for engraving. Photographs should be clear and sharp in all details for best half-tone or photogravure reproductions.

The accompanying star map, for April, contains the paths of the planets visible for the month. We have extended them to cover six months, instead of one month, as heretofore, so as to show the changes in the apparent paths, in a way that might not be so well or easily related from month to month by the other way. Dr. Wilson has also added the paths of the four oldest planetoids, Ceres, Pallas, Juno and Vesta. They are all in favorable position for observation, as Ceres passed opposition March 13, appearing with magnitude 7.1; Pallas was in opposition February 7, magnitude 6.6; Juno will reach opposition May 7, being then of 10th magnitude; and Vesta was at opposition March 10, with magnitude of 6.5.

It is a curious fact that the *Berliner Jahrbuch*, for 1894, contains an ephemeris of only one of these planetoids, viz: that of Juno, the faintest of all of them. In order to give the paths of the others, Dr. Wilson and Mr. Sivaslian have computed ephemerides of all the others for six months, especially for this map and for the readers of this journal. Those who know how much computation this involves will appreciate their work. The suggestion that we add to the star-maps the paths of the brighter planetoids first came from Messrs. Poole Brothers, who are furnishing, from month to month, enough copies of these beautiful maps for the entire large edition of this publication. Their interest in the success of this new periodical is second to none outside of those immediately connected with its management.

We have received a number of letters concerning the Poole Brothers' Planisphere and Handbook, asking either for information about them as aids to naked-eye star study, or study of easy objects with the opera glass or small telescope, and we have uniformly recommended them as among the latest and best of such helps. One correspondent noticed that certain of the white nebulæ were described in the Poole Handbook as being star clusters, and doubtless could be resolved if sufficient power be applied. Good authority maintains this, but the most reliable spectroscopists say the spectroscope can not decide that point. The evidence is neither *for* nor *against*, but the spectrum is simply *expressionless*. While good authority in astronomy differs in this matter, we can not certainly say that either is right or wrong.

The evening skies during these months, on moonless nights, are grand in the extreme. With such helps at hand as the star-charts, given in later numbers of this journal, and the excellent articles by Professor Upton on Constellation Study, any person at all interested in knowing about the stars can easily gain a good knowledge of them if he will but read and observe. Half-hours so spent will be a life-long pleasure.

We are pleased to notice that the study of variable stars, under Mr. Parkurst's direction, is gaining wide and favorable attention. Letters from Nova Scotia and Tennessee attest it very plainly.

Any subscriber knowing of persons interested in the study of Elementary Astronomy, and not already a reader of this publication, will confer a favor by sending the names to the publisher, that sample copies may be forwarded for examination.

Persons interested in extending the circulation of POPULAR ASTRONOMY will be furnished, free of charge, sample copies and circulars of information.

MAP OF THE
CONSTELLATIONS
VISIBLE APRIL 15,
AT 9 P. M.

REDUCED FROM SECTION OF
POOLE BROTHERS' PLANISPHERE.

BY PERMISSION.

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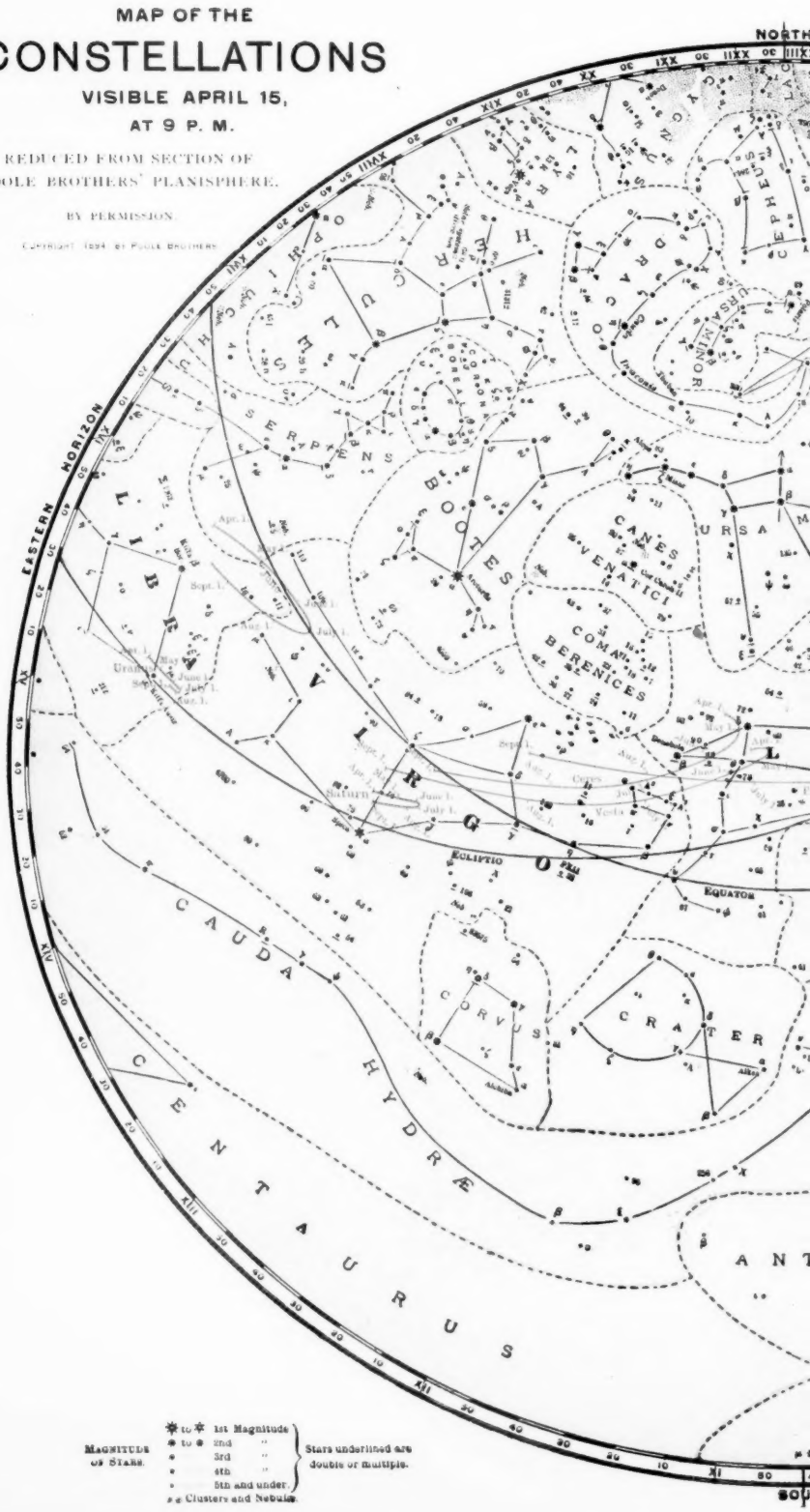
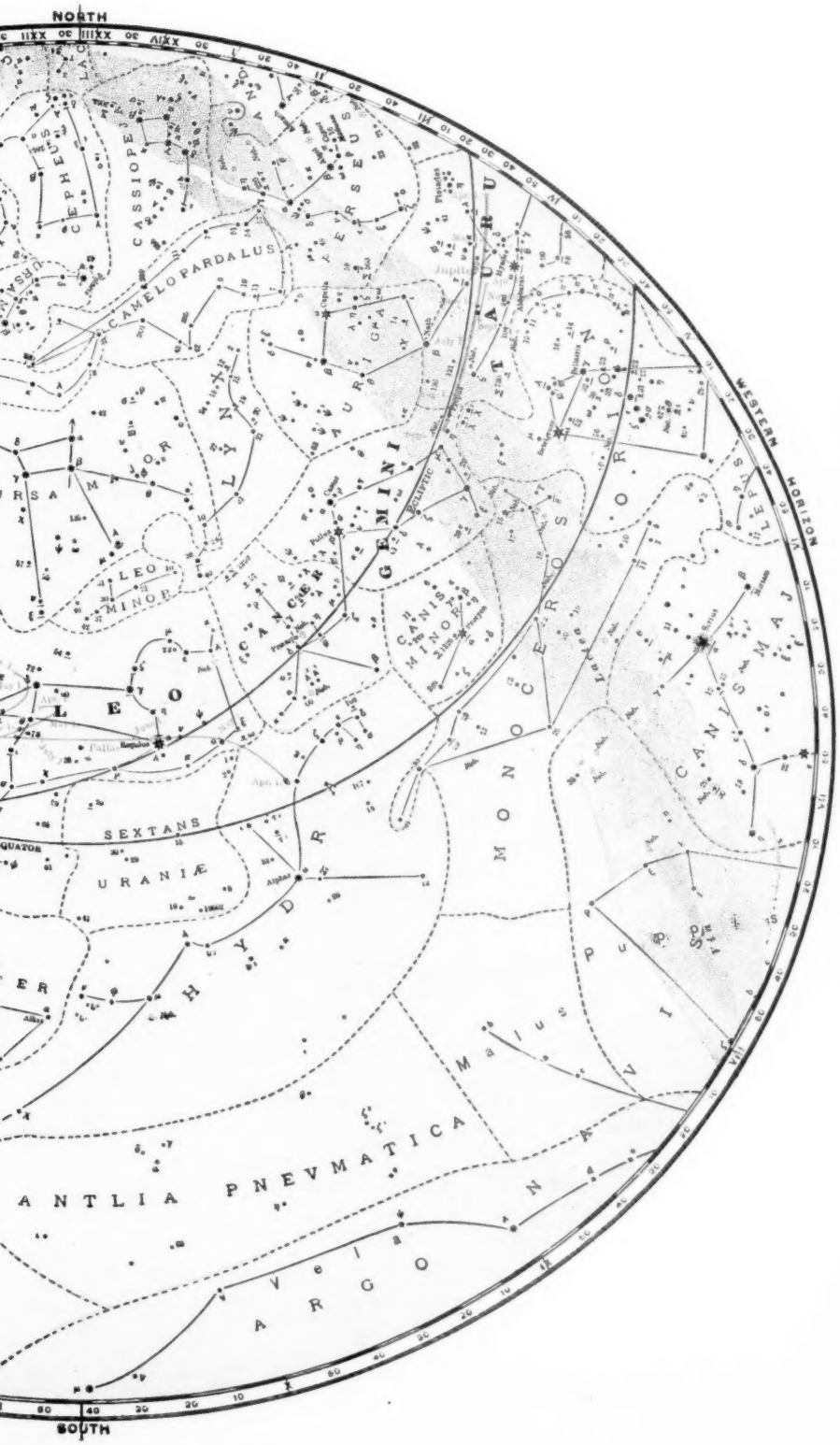


MAGNITUDE OF STARS.

- ✱ to ✲ 1st Magnitude
- ✱ to ● 2nd "
- ● 3rd "
- ● 4th "
- ● 5th and under.

Stars underlined are double or multiple.

⁂ Clusters and Nebulæ.


NORTH
CASSIOPEIA
CEPHEUS
CAMELOPARDALUS
PERSEUS
AURIGA
TAURUS
GEMINI
LYNX
URSA MAJOR
LEO MINOR
CANCER
LEO
CANIS MINOR
ORION
LEPUS
CANIS MAJ
MONOCEROS
SEXTANS
URANIÆ
HYDRA
Malus
Puppis
ANTLIA PNEVMATICA
Vela
ARGO NAVIS
WESTERN HORIZON
EQUATOR
SOUTH